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BULLETIN OF MARINE SCIENCE
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AN ECOLOGICAL STUDY OF THE GULF OF MEXICO FISHES, IN THE VICINITY OF CEDAR KEY, FLORIDA

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ABSTRACT

An investigation of the fishes which inhabit the extensive shallow areas and channels in the vicinity of Cedar Key, Florida, was made from June, 1950, through May, 1951. The muddy sand-bottomed "flats" supported rich growths of vegetation during the warm months and a varied and abundant fish fauna found food and shelter among the plants. Over 13,000 specimens were collected and 122 species representing 100 genera and 58 families are included in an annotated list. The kinds and numbers of fishes varied seasonally, the greatest variety of species and abundance of individuals were found during the summer and early fall. Breeding occurred generally during the spring months. Food studies indicated that microcrustaceans, malacostracans, shrimps, annelid worms, mollusks, crabs, and fishes were the principal food organisms utilized by the shallow water fishes. Of the environmental factors, salinity did not appear to be critical while water temperature and bottom composition seemed to exert considerable influence on the local fish population.

The Cedar Key fauna was found to consist predominantly of species more characteristically associated with temperate climate. However, comparison with the fauna of Texas and North Carolina shows a considerably greater proportion of West Indian forms at Cedar Key.

INTRODUCTION

The shore zones of the sea, the so-called "eulittoral" of the marine major community, are often regions of rich and varied plant and animal life. Where the line of contact between land and sea is mar-

gined by broad, muddy or sandy expanses of shallow ocean floor, an abundant vegetation may develop, and this provides food, oxygen, and protection for myriads of organisms which may be intricately interrelated in complex ecological subcommunities. While this rich shore zone retains certain characteristic features wherever found, its immense linear extent and the wide variety of local conditions that it traverses are reflected in marked changes in the details of the community from one place to another.

On the drowned shore south of the Suwannee mouth in the vicinity of Cedar Key, Florida, the broad, comparatively shallow flats support an impressive assemblage of plants and animals. Partly because of the shallowness of the water and partly because of its location with respect to the drainage system of the peninsula, this region is by no means a stable environment, and the organisms in it are subjected to variable conditions, some of which are adverse to particular groups while at the same time favorable to others. Wide fluctuations in temperature and salinity act to the detriment of strictly stenothermic or stenohaline plants and animals, the ebb of tides periodically exposes parts of the shallow area, thereby affecting the plants and animals, and wave action, though limited in the protected areas studied, also exerts considerable influence on the biota, especially on the sessile and planktonic forms.

The present report is concerned primarily with the fishes of the Cedar Key area. The major objective of the study was to ascertain what species compose the fish population in the area, their local habitat distribution, and the relative abundance of the species in the habitats occupied. A second objective was to determine some of the basic physical and biological factors in the environment and how the various species respond to seasonal or sporadic changes in those factors.

Observations on breeding, life history, food, and growth were made. Morphologic study was restricted to the occasional case in which it was necessary to clarify the taxonomic status of a form.

To augment the significance of this faunal study, it was desired to compare this area with others in which similar investigations have been made. Thus, frequent references are made to Gunter's study (1945) of bays of the Gulf along the Texas coast; to a study by Kilby (unpublished manuscript, 1950) of the fishes of the coastal marshes at Cedar Key and Bayport, Florida; to an account of the fishes of

Tortugas by Longley and Hildebrand (1941); to *The Fishes of North Carolina* by Smith (1907); to *Fishes of Chesapeake Bay* by Hildebrand and Schroeder (1928); to Jordan's description (1884) of the fishes of the Key West area, and to a report on the Cedar Key fishes by Jordan and Swain (1884).

After several months of exploratory collecting and reconnaissance in the area, the investigation forming the basis for the present report was begun in June, 1950. Collecting stations were established in various situations and regular collections were made twice monthly, through May, 1951, insofar as weather or other factors permitted.

I should like to express my appreciation to many persons at the University of Florida who contributed to the completion of this study. Grateful acknowledgement is accorded Professor W. C. Allee, Head of the Department of Biology, for his interest and advice, and Professor Archie Carr for the time, suggestions, and invaluable criticisms which he gave. Appreciation is also expressed to Professor H. B. Sherman, Dr. C. J. Goin, Dr. E. L. Pierce, and Dr. R. A. Edwards. I am indebted to former associates at the University of Florida whose spirit of cooperation and natural curiosity prompted them to accompany me on collecting trips, thereby lightening the chore of pulling in the trawl.

Gratitude is expressed to Dr. Leonard P. Schultz and the staff of the Division of Fishes, United States National Museum, and to Mr. Isaac Ginsburg, of the United States Fish and Wildlife Service, for their assistance accorded me during a visit to the museum, to Dr. Reeve M. Bailey, University of Michigan Museum of Zoology, for taxonomic suggestions, and to Dr. Gordon Gunter, Institute of Marine Science, Port Aransas, Texas, for helpful criticisms and examination of the final manuscript.

Mr. St. Clair Whitman and Mr. H. H. Jenkins of Cedar Key granted many favors and personal kindnesses, and Mr. R. B. Davis permitted me to examine his commercial catch records.

To my wife, Eugenie Reid, gratitude is expressed for her editorial aid and numerous other considerations.

THE CEDAR KEY AREA

PHYSIOGRAPHY AND VEGETATION

The Cedar Key Area, as limited herein, includes a group of marsh and offshore islands lying approximately in Latitude 29°08′N. and Longitude 83°02′W., or about 90 miles north-northwest of Tampa. These offshore islands, together with smaller islands of the marsh and mud flats, and even the main-

land shoreline, reflect strongly the geologic history of Pleistocene fluctuations of sea level and the work of present-day winds and tides.

The entire coastline of salt marsh and mud flats in this region is considerably dissected by channels and bayous forming a continuous system of branching and interlocking water courses, presenting a typical example of a drowned coastline. Some of these water courses continue seaward as channels which cut through the broad shallow areas produced by the gentle slope of the bottom. These vast shallow areas are known locally as "flats" and, together with the channels, islands and oyster bars, are the dominant features of the open water areas. Along this section of the Gulf coast depths of less than three fathoms

FIGURE 1. Map of the Cedar Key, Florida Area. Seventeen trawl collecting stations are shown. Abbreviations are: SF, Shallow Flat; DF, Deep Flat; CH, Channel; C, Cove. One shallow-water seine station off a sandy beach is shown (B).

extend from shore outward as far as 10 or 11 miles, while the 10 fathom contour occurs at an average of 28 to 30 miles.

Superficially the flats all seem to be similar, but actually they vary in bottom composition, in depth, and in other respects. In the present study, depth is considered the limiting characteristic, and two types of flats are recognized. Shallow flats are those broad areas in which the bottom is exposed during the lowest winter tides and at which time the vegetation almost vanishes completely. These flats usually are covered by water from two to three feet in depth at mean low tide. Deep flats are similar broad areas in which the bottom is not exposed during the lowest winter tides and which may be from three to six feet below the surface of the water at mean low tide. Sparse green or yellow vegetation is usually present on deep flats in winter.

Characteristically, the bottom on the shallow flats is composed of more or less hard-packed sand with a scattering of shell fragments. These flats support rather luxurious growths of Cuban shoal weed (*Halodule wrighti*), although not to the exclusion of other spermatophytes such as manatee grass (*Cymodocea manatorum*) and turtle grass (*Thalassia testudinum*). Widgeon grass (*Ruppia maritima*) sporadically occurs in scattered growths. As would be expected in view of their elevation, the shallow flats are the first to become bare in the winter. The vegetation usually dies after a sustained period of cold weather or a severe cold snap. The shallow flats then remain barren until early spring, when limited amounts of various species of algae appear and remain the dominant vegetational features for two or three months, after which the spermatophytes return and predominate through the warm months.

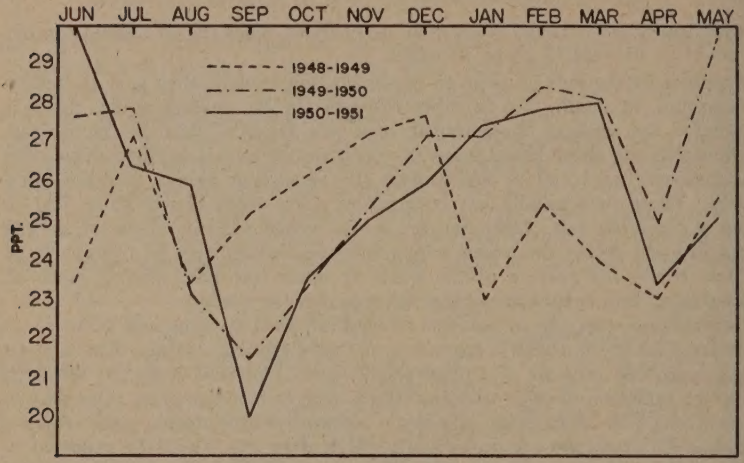
On the deep flats the bottom is usually composed of muddy sand or nearly pure mud which supports lush growths of manatee grass, with some intermixture of the other spermatophytes. *Halophila engelmanni,* although not abundant anywhere, appears to thrive best in these deeper areas. Being deeper, these flats usually are subject to less vigorous wave and tidal action than the typical shallow flats. It is on these flats that the abundance of such algae as *Laurencia papillosa, Codium decorticatum,* and *Gracilaria confervoides* measurably increases in early spring. The brown alga (*Sargassum pteropleuron*) is found on deep flats and channel edges.

The channels are submarine trenches, some of which converge near Cedar Key. The bottom composition of the channels is mostly mud, with large amounts of oyster and other shell debris usually present. In several places the channel bottoms are quite rocky, the rocks being outcroppings of the underlying formations or loose fragments of these. Vegetation is usually sparse or nonexistent, except for scattered growths of algae.

Another conspicuous togographic feature of the open waters is the oyster bars which rise above the shallow flats. Although mostly bare, some of the bars are dominated by *Spartina alterniflora,* while others support rather abundant stands of black mangrove (*Avicennia nitida*).

HYDROGRAPHY

Salinity. Figures 2 and 3 show that the mean monthly salinity range in shallow waters at Cedar Key during 1950-1951 amounted to 10.1 ppt., although a con-



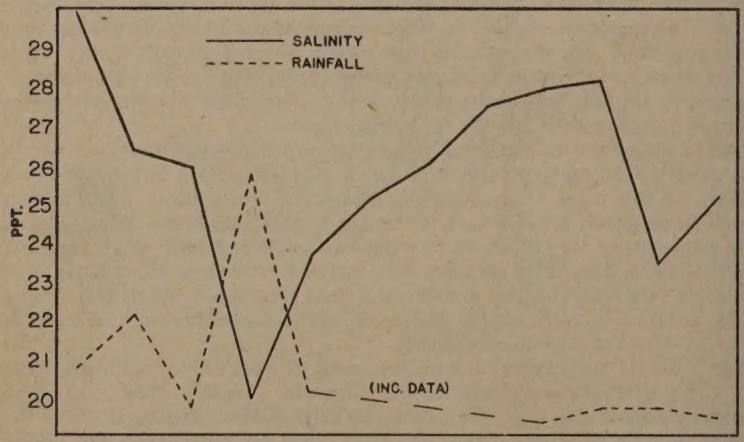


FIGURE 2 (Above). Monthly Mean Salinities for Three-Year Period. Salinities are expressed as parts per thousand (ppt.).

FIGURE 3 (Below). Monthly Mean Salinities and Precipitation for 1950-1951. Salinities are expressed as parts per thousand and precipitation in inches.

siderably greater diurnal variation was noted. The lowest salinity occurred in September, 1950. The reading was 9.7 ppt. and was taken on September 9, two days following a severe hurricane which centered over the area for approximately 48 hours. Although data were not obtained during the hurricane, 24 inches of rainfall were recorded on September 6. The highest daily record was noted in June, when the salinity was 33.8 ppt. Generally, the higher salinities

were experienced during the winter and early spring; lowered salinities were noted in late spring and in late summer, which are usually periods of heavy rainfall. The mean annual salinity in the shallow waters at Cedar Key was 25.7 ppt. during 1950-1951. This was considerably lower than the salinity of offshore waters which Pierce (1951, 210) has shown to be approximately 32 ppt. at 15 miles out.

Salinities taken on successive ebb and flood tides normally varied not more than one or two parts per thousand. Similarly, only slight differences existed between salinities observed on flats and in channels at a given time.

Figure 2 demonstrates monthly salinity variations over a three year period. It will be noted that the salinities in 1949-1950 and 1950-1951 follow similar seasonal patterns. The curve for 1948-1949 deviates considerably, however. The lowered salinities during winter and spring were due, doubtless, to increased precipitation in winter and spring of that year.

The major factors causing fluctuations of salinity in the shallow inshore waters are local rainfall and surface runoff from the mainland. Figure 3 shows a close correlation between rainfall and salinity during the period of investigation. The lowest salinities were recorded during the spring, when numerous scattered showers occurred, and in late summer, the season of frequent intense squalls of rather short duration. The effect of hurricanes in early fall is particularly noticeable in Figures 2 and 3 wherein monthly mean salinities for a three-year period are shown. The high salinity shown in September, 1948, was due to slight precipitation, whereas in the same period in 1950, a very intense hurricane, previously mentioned, occurred. Highest salinities in the shallow water area were found during the winter months when rainfall is at a minimum. Table 1 shows monthly salinity ranges during the period from June, 1950, through May, 1951.

TABLE 1. MONTHLY MEANS AND EXTREMES OF TEMPERATURE AND SALINITY AT CEDAR KEY, FLORIDA

	Temperature		*Salinity*	
Month 1950-1951	*Range ° C.*	*Mean ° C.*	*Range ppt.*	*Mean ppt.*
June	23.9-32.2	28.3	24.6-33.8	30.0
July	25.6-31.7	28.9	23.5-29.1	26.3
August	25.6-29.4	28.3	20.0-29.0	25.9
September	22.8-28.9	26.1	9.7-24.0	19.9
October	21.1-25.0	23.3	18.3-28.6	23.5
November	7.8-24.4	17.2	17.8-30.6	25.0
December	8.3-18.3	12.2	23.9-27.6	25.9
January	7.2-16.7	13.3	24.8-28.8	27.4
February	8.3-21.1	15.0	25.5-31.0	27.8
March	14.4-22.8	18.9	20.4-31.8	28.1
April	16.1-25.6	20.0	14.4-30.0	23.3
May	21.7-26.7	24.5	20.1-28.4	25.2

Data are based on an average of twenty-five daily observations per month, taken by U. S. Coast and Geodetic Survey at Cedar Key Tide Station.

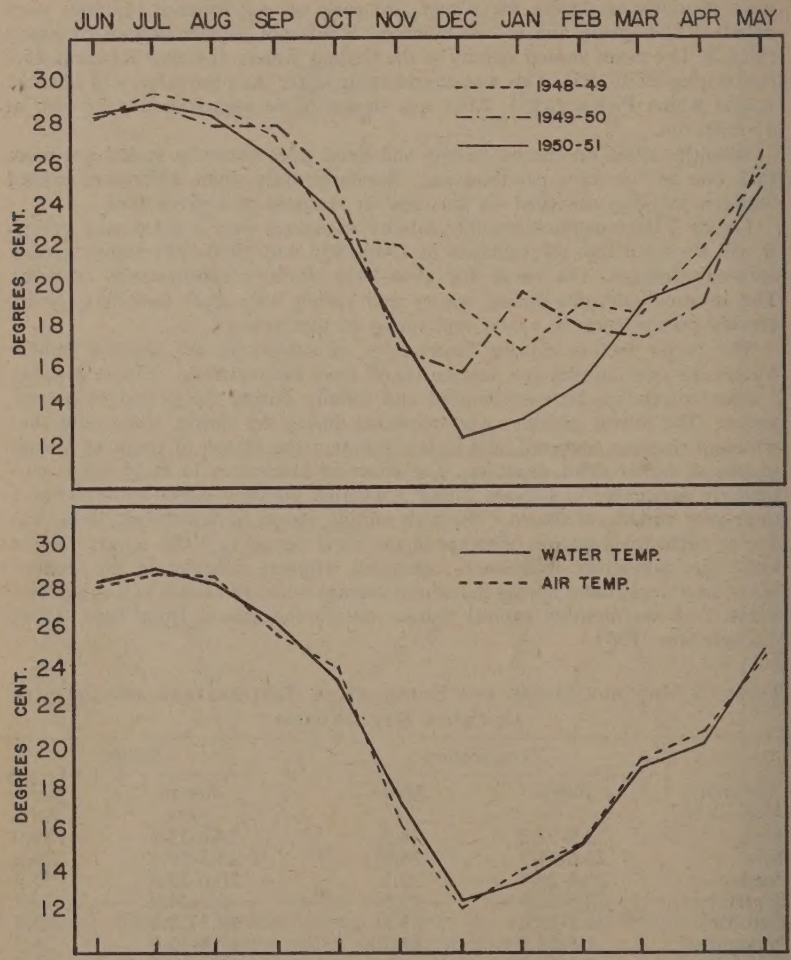


FIGURE 4 (Above). Monthly Mean Water Temperatures for Three-Year Period.
FIGURE 5 (Below). Monthly Mean Water and Air Temperatures for 1950-1951.

Two rivers in the vicinity of Cedar Key also contribute to the dilution of the inshore sea waters of the region. The Suwannee River discharges into the Gulf approximately 16 miles north of the area of the study, and during the rainy season its volume is great. The Waccasassa River, 13 miles east of Cedar Key, drains much of the low, flat terrain of the mainland near Cedar Key. Numerous small creeks also contribute fresh water to the shallow zone

near shore. Pierce (*loc. cit.*) has shown that the diluting effect of streams is not nearly so pronounced in offshore water (15 miles) as it is in the inshore areas, the offshore salinity gradient during the 15-month period considered by him having been approximately four parts per thousand, as compared with a range of nearly 10 ppt. one-half mile offshore.

Temperature. The shallow water in the area is subject to wide fluctuations in temperature. The lowest temperatures recorded during the present study were noted in late November (7.8°C.) and in January (7.2°C.). The cold periods did not last for long, however, and the water warmed rather rapidly. The highest temperature occurred in June, when the water was 32.2°C. On the average, the temperature fluctuations were not so drastic, the range of monthly means being from 12.2° to 28.9°C. (Figure 4). The annual mean surface water temperature from June, 1950, through May, 1951, was 21.3°C.

Figure 5 shows that throughout most of the year the surface water temperature closely approximates atmospheric temperature, the most noticeable divergence being in summer, when the water is warmer than the air. The more or less characteristic lags between atmospheric cooling and cooling of the water, and again in the warming process, are evident in the figure. Moody (1950: Fig. 2) obtained a similar curve for the Cedar Key area during 1948-1949.

As would be anticipated, the inshore waters appear to be more sensitive to atmospheric changes than offshore waters. The shallow waters begin to cool about August, with the change toward lower temperatures being rather gradual during the first two or three months, after which cooling occurs rapidly. Short cold snaps are reflected in sudden drops in the water temperature, and these are, of course, stronger in the shallow area than in deeper waters, although after the cold spell has passed the inshore waters warm up quickly. Pierce (*op. cit.*, 209) showed that from July through December the shallow waters cool more rapidly and are generally two to three degrees colder than the surface waters 15 miles offshore. Warming in spring follows the same trend, in that the shallow water warms more rapidly than the offshore waters, although the differences in temperatures are not great.

Temperature observations made on flood and ebb tides showed only slight differences. Where noticeable differences were obtained, the hours at which the readings were made were such that the differences might have been due to insolation.

Circulation. The chief factors producing circulation in the inshore waters are tides and wind. Influx from the two previously mentioned rivers may have some effect, and small, local eddy currents may be set up as the tides flow past islands or oyster bars. *The Current Charts of Central American Waters* (U. S. Navy Hydrographic Office, Washington, D. C.), indicates a slight, northward-moving current some distance offshore, and this current may contribute to the circulation of the inshore waters.

The annual mean range of tide in the Cedar Key area, as shown in the Tide Tables of the Coast and Geodetic Survey, 1951, is 2.5 feet, the spring range of tide being 3.3 feet. During the summer season of higher tides the velocity of flow is quite rapid.

Winds have a strong influence on tidal rhythm and intensity in the shallow water of the Cedar Key area. A strong wind from the land over a period of a few days can maintain a continuous low tide despite a normal tidal tendency to rise. Likewise, a strong, consistent wind from the Gulf for several days will keep the tide high and prevent, at least to some extent, the occurrence of low tides.

Mixing of the shallow waters of the inshore area, due to one or more of these elements of circulation, appears to be a conspicuous and regular process. One of the results of mixing is the absence of thermal and salinity stratification. Wind is particularly important in this respect. Waves of considerable height occur in the inshore waters, especially during the late summer squalls. Throughout most of the summer, detached water plants are to be seen floating on the surface, and often in windrows of considerable extent, giving evidence of the work of waves and wind.

Turbidity and Color. As would be expected in shallow areas where much of the bottom is mud or muddy sand, and where a large part of the tidal flow is into marsh areas of mud flats, turbidity is generally high and the water colored. At no time during the investigation was visibility more than three or four feet, and more often it was less. The water was frequently colored a dirty brownish or yellowish with much suspended detritus present. Turbidity in the inshore waters contrasts considerably with the offshore waters in that depth of visibility is increased in the latter to as much as three fathoms at times.

EQUIPMENT, METHODS, AND TECHNIQUES

FIELD EQUIPMENT AND PROCEDURE

An otter trawl of standard design proved to be the most efficient single piece of collecting gear and was used for most of the collecting. This trawl had a spread of 15 feet, with the bag trailing eight feet. The mesh of the bag was three-eighths inch on the side, or three-quarter inch stretched. The bag was equipped with a draw string in the trailing end to facilitate emptying the contents.

Insofar as water and weather conditions permitted, each trawl haul was timed to be of five minutes' duration. When used on wide flats, the trawl was pulled in a semi-circle; if dragging in a channel, the course of the channel was followed.

A beam trawl was used occasionally for exploratory collections. This type of trawl was kept open by means of a rigid bar connecting two metal runners approximately five feet apart. A six foot bag of one-quarter inch mesh was attached to the beam, the underside of the mouth of the bag being weighted to insure its dragging the bottom.

The boat used was a fishing skiff powered by a ten horsepower outboard motor.

Many small specimens included in the present study were collected with a push net by R. Kirk Strawn, incidental to his sampling of the seahorse population. The push net consisted of one-eighth inch mesh netting hung from a wooden frame, the sides of which were four feet long. The net was pushed along the bottom, lawn mower fashion, by means of a handle six feet in length.

The young of several species of fishes captured in the push net did not appear in trawl hauls until the following month.

Other types of collecting gear included wire strainers, dip nets, a trammel net, and a cast net.

Supplementary information on the larger fishes of the area was obtained through periodic visits to commercial fish houses and frequent examinations of the catches of commercial fishermen. Much of the data on gonadal condition and food of adult fishes was thus obtained.

Specimens in the collection of the Department of Biology, University of Florida, were examined also and in some instances these represent the only specimens of a particular species from the Cedar Key area.

COLLECTING STATIONS

Seventeen regular collecting stations were established and visited on an average of twice monthly during the study. Stations were located on each of the previously described major ecologic areas of the open water except the oyster bars. In addition to the regular stations, several areas were investigated in exploratory collecting. The stations are shown in Figure 1 and are listed, with explanatory notes, in Table 1a. Collections in the regular stations were made with the trawl during high water only, since the use of boat and trawl was not practicable at low tides. Most of the collections were made during the daytime, although some sampling was done at night.

TABLE 1A

LISTING STATIONS BY TYPE AND NUMBER

Type	*Number of Stations*	*Designation on Fig. 1*	*Remarks*
Channels	4	CH	Bottom mostly of mud and sand with shell and rock. Bottom at CH-1 sandy mud.
Shallow Flats	6	SF	Generally similar although subject to local variations resulting from currents and winds. Exposed during winter low tides.
Deep Flats	5	DF	Occasionally received large amounts of silt and mud. Algae very abundant seasonally. Not exposed during winter low tides.
Coves	1	C	Sheltered regions within curve of crescent-shaped islands.
Beach	1	B	Typically sandy bottom in shallow water.

LABORATORY TECHNIQUES

The specimens in each jar containing a collection were sorted into species, each individual was measured, and the results were tallied on a species data sheet. All of the specimens of the same species were labeled, tied in cheesecloth, and placed in containers of fresh formalin (5 per cent) by species. The total

numbers of specimens of each species in a collection were entered on the reverse side of a McKee Keysort card bearing field data. Specimens of each species were examined for gonadal development, stomachs were examined for food, and morphological characters were studied and measured.

Salinities were determined from densities and temperatures taken in the field, and, in order to provide a check, two samples of water were taken regularly from the same localities and brought into the laboratory for more accurate salinity determinations. In the field, a sample of water was taken in a glass cylinder from just below the surface and the density obtained by means of a sea-water hydrometer calibrated in 0.0001 gm./cc. The temperature of the water in degrees Centigrade was ascertained at the same time with a tube thermometer.

Air temperatures and rainfall data were obtained from the *Bulletin of Climatological Data* for 1950 and 1951, U. S. Department of Commerce, Washington, D. C.

Daily density and temperature data for the period of the investigation, and monthly maximum, minimum, and mean data for the preceding two years, were obtained from the U. S. Coast and Geodetic Survey, Washington, D. C. These data were taken at the Cedar Key tide station, which was located on the city pier, approximately in the center of the area studied.

PRESENTATION OF DATA

The natural history and physical data pertaining to each species are presented in the following pages in an annotated list of species. In all instances, the regular and exploratory collections of specimens have been designated as such in order to avoid vitiating the quantitative significance of the monthly catch records.

In presenting taxonomic characters, certain abbreviations are used. The count of gill rakers on the first gill arch is expressed as the number of rakers on the upper limb plus those on the lower limb, thus: 6+12 to 13=18 or 19. In a scale count expressed as 10-43-13, the "10" refers to the number of scale rows between the origin of the dorsal fin and the lateral line, the "43" to the scales in the lateral line, and the "13" to the number of rows between the lateral line and the origin of the anal fin. The spines and rays of the vertical fins are numbered in Roman and Arabic numerals, respectively. Thus the formula, VIII, 23, means 8 spines and 23 soft rays.

Unless stated otherwise, all lengths of fishes are presented as standard length, which is defined as the distance from the tip of the snout to the middle of the caudal base.

The classification and names of categories are essentially those of Jordan, Evermann, and Clark (1930). However, certain systematic suggestions made by Dr. Reeve M. Bailey, University of Michigan Museum of Zoology, and Mr. Isaac Ginsburg, United States Fish and Wildlife Service, Washington, which seemed to add simplicity and clarity to the local list, were incorporated.

THE FISHES OF THE CEDAR KEY AREA

CHONDRICHTHYES

EUSELACHII

Carcharhinidae

Scoliodon terranovae (Richardson). Sand Shark. Sharks were rather common in the Cedar Key area from March through early November. Several specimens of this species were examined during the summer of 1950, when they were caught on a line from the city pier. The sizes usually ranged from two to three feet, although larger individuals were observed in the water.

Springer (1939:18) stated that it is possible that two species of this shark may be involved in the population and that both are regularly present in South Florida waters.

Carcharhinus limbatus (Müller and Henle). Spot-fin Shark. A 26-inch male, provisionally identified as this species, was taken by hook from the city pier in July. Bigelow and Schroeder (1948:351) stated that the range of this species could be outlined only within broad limits, due to taxonomic uncertainties, but that it is one of the commoner, if not the commonest, pelagic shark around southern Florida.

Sphyrnidae

Sphyrna diplana (Springer). Hammerhead Shark. Hammerhead sharks occurred commonly in the area, particularly during the spring and summer months after the shallow waters had warmed. None was taken in the trawl, although specimens of nearly six feet in length, caught by hook-and-line, have been examined on the city pier.

Springer (1939:32) found this species to be more abundant during the winter than in summer at Englewood, Florida.

Sphyrna tiburo (Linnaeus). Shovel-nose Shark. No shovel-nose sharks were captured in the trawl during the period of study at Cedar Key. Specimens were caught occasionally on hook-and-line during the warm months. Three specimens, taken from the channel off the city pier, were examined. One individual taken in July, was a female, 33 inches in total length. The surface temperature at the time of capture was 30.6°C., and the salinity was 25.6 ppt. Two of these sharks were captured in August (temperature: 28.9°C.; salinity: 29.0 ppt.). One, a female, was approximately 40 inches in total length. The second August specimen was an immature individual, 288 mm in total length.

Breeding apparently occurred in the late spring in the Cedar Key area. The larger of the August specimens gave birth to three young as she was being pulled onto the pier; the young were 278, 280, and 293 mm in length. The other specimen (288 mm long) taken in August was caught about four hours after the adult and was probably one of her litter.

Springer (1939:30-31) found specimens up to three and a half feet long to be common at Englewood, Florida, at some seasons, although he had no records of summer captures.

BATOIDEI

Pristidae

Pristis pectinatus Latham. Common Sawfish. This species was not taken during the investigation. Evidence for the occasional occurrence of sawfish in the Cedar Key area is to be found in the "saws" adorning the porches of commercial fishermen. Jordan and Swain (1884:230) reported *P. pectinatus* for Cedar Key and called it rather common.

Rhinobatidae

Rhinobatos lentiginosus (Garman). Guitarfish. One specimen, a male approximately 30 cm. in total length, is in the private collection of Mr. St. Clair Whitman of Cedar Key. It was taken from the flats by commercial fishermen.

Coloration in the specimen (preserved in formalin) consists of numerous small white spots on a light brown ground color. The area before the eyes is much lighter than the rest of the body, with two parallel darker stripes running from the eyes to the snout.

Rajidae

Raja texana Chandler. Texas Clear-nosed Skate. Several skates, provisionally identified as *R. texana*, were caught from the shallow flats and shallow waters of beach areas in July, when the mean monthly surface temperature was 28.0°C., and the salinity was 26.3 ppt. Another specimen was taken from a channel approximately sixteen feet in depth in December at a temperature of 10.0°C. and salinity of 24.8 ppt.

One individual, 469 mm in total length, contained numerous annelids. Breder (1929:31) stated that this species feeds chiefly on crustacea and fish.

The seasonal behavior of this species probably follows that of *Dasyatis sabina*, which migrates to deeper water with the approach of cool weather. Such movement would account for the presence of the one specimen in the channel and the scarcity of the skate on the flats in December.

Dasyatidae

Dasyatis sabina (LeSueur). Stingaree. Probably the most common ray in the area, this species occurred in the shallow waters of the flats and off sandy beaches throughout most of the year. Numerous individuals, ranging up to 450 mm. in total length, were taken in the trawl, and larger specimens were observed as they took flight from the approaching boat.

By November, when the mean monthly temperature had reached 17.2°C. and the salinity 25.0 ppt., few stingarees were observed in the shallows. Several specimens were collected during the coldest months from deeper channel areas. Individuals approximately 350 mm in total length were taken from the main ship channel south of Seahorse Island in depths of 16 to 18 feet in December, when the surface temperature was 10.0°C., and the salinity was 24.8 ppt. A single example, 450 mm in total length, was captured in the trawl in the channel in January. The temperature of the water was 16.5°C. and salinity 26.8 ppt. The earliest recorded occurrence of stingarees on the flats was late February (temperature: 19.5°C., salinity: 29.8 ppt.), when one was caught in the trawl. Thus it appeared that the rays left the flats with the approach of

cold weather and sought deeper water. Gunter (1945:22) has observed similar seasonal movement of this species on the Texas coast. He noted (*loc. cit.*) that stingarees left Copano Bay in the fall, and none was taken from November to February. Two were collected in a channel in Aransas Bay in February. Gunter believed that rays leave the bay waters in response to temperature drop rather than salinity change. This conclusion is further supported by evidence from the present study which indicated that rays were abundant during periods of highest and lowest salinity.

Pteroplatea micrura (Schneider). Butterfly Ray. A single specimen of this species was captured in the trawl from shallow water near a sandy beach at Piney Point in June. The surface temperature at the time of collection was 28.5°C., and the salinity was 31.6 ppt.

The individual was 172 mm in total length and 425 mm between the acutely pointed outer edges of the disk. Ground color of the ray was light-brownish with irregularly placed spots of darker color, these spots being more concentrated toward the trailing edge of the disk. The much reduced tail was marked with four wide spots of darker color which did not extend onto the ventral surface.

Gunter (1945:23) caught only two of this species in trawls over a period of two and one-half years on the Texas coast. Gunter (*loc. cit.*) quoted J. L. Baughman as saying that this species is fairly common in the Gulf near Galveston. The butterfly ray was not reported by Longley and Hildebrand (1941) for Tortugas. Smith (1907:45) stated that it is numerous at Beaufort, North Carolina, and feeds on fish, razor clams, or shrimp. Hildebrand and Schroeder (1928:68) found the species to be common in Chesapeake Bay from May until November.

Aetobatidae

Aetobatus narinari (Euphrasen). Spotted Eagle Ray. An eagle ray, provisionally identified as *A. narinari*, has been reported by several reliable observers. Individuals were seen during summer when they made long gliding leaps out of the water. Commercial fishermen reported capturing the ray in nets.

OSTEICHTHYES

GLANIOSTOMI

Acipenseridae

Acipenser oxyrhynchus Mitchill. Sturgeon. This species is included in the list of Cedar Key fishes on the basis of one specimen, Number 49535, in the collection of the Florida State Museum, Gainesville. It bears the label "Cedar Key, February 12, 1931. P. M. Boothby, collector."

Identification of the specimen is based on characters given by Hildebrand and Schroeder (1928:72-73). The Cedar Key example, 395 mm in length, has 38 rays in the dorsal fin, and 24 in the anal. There are 10 dorsal shields, 28 lateral shields, and 13 ventral shields. The top of the head is rather concave with a smooth median area at the base of the concavity.

Local fishermen were vague concerning the presence of the fish in the area,

although one man said that he had seen "runs" of sturgeon offshore, and that they went into the Suwannee River.

Gowanloch (1933:411) says, "Louisiana fishermen occasionally capture large common sturgeon in the waters around the mouth of the Mississippi River and also in the Mississippi Sound." Hildebrand and Schroeder (*op. cit.*, 76) stated that the habitat of the species is: ". . . on the Atlantic coast of America from the St. Lawrence River to the Gulf of Mexico. Also, once recorded from Hudson Bay, and the north-western coast of Europe, if the American and European sturgeons are considered identical."

A considerable fishery for sturgeon has existed in some of Florida's Gulf estuaries. This industry is at present centered around the Apalachicola River mouth.

HOLOSTEI

Lepisostidae

Lepisosteus platyrhincus De Kay. Florida Spotted Gar. Although no gars were taken in the trawl or seines during the investigation, several individuals were observed and their presence further attested by commercial fishermen.

Kilby (1950:49) did not record gars at Cedar Key, although he found them to be numerous in the marsh at Bayport, Florida, and indicated that they occasionally feed in the open waters of the Gulf, at least a mile offshore.

Many species of gars are apparently tolerant of varying salinities. Gunter (1945:23-24) found *L. productus* on the Texas coast in a salinity of 3.3 ppt. and *L. spatula* in salinities ranging from 3.2 to 31.2 ppt. Smith (1907:56) found *L. osseus* sometimes entering salt water off North Carolina. Hildebrand and Schroeder (1928:77) stated that *L. osseus* was uncommon in Chesapeake Bay.

ISOSPONDYLI

Elopidae

Elops saurus Linnaeus. Ladyfish, Tenpounder. This species was not taken in the trawl in any regular collections. Specimens approximately 360 mm in length were taken on hook-and-line in September, 1949, when the mean monthly surface temperature was 27.7°C., and the salinity was 21.4 ppt. Young fish, 106 to 126 mm in length, were caught in marsh pools with a seine in June, 1951. Kilby (1950:50) found young ladyfish in the marshes at Cedar Key from April through July. Gunter (1945:24) reported specimens on the Texas coast from May through October.

No breeding adults were observed during the investigation, although the presence of young fish in June suggested an early spring spawning season in the Cedar Key area.

Stomach analyses of examples of this species revealed unidentified fish remains. Gunter (*op. cit.*, 25) found the diet of Texas specimens to consist of shrimp (*Penaeus setiferus*) and pinfish (*Lagodon rhomboides*).

Field observations indicated that adult ladyfish were not overly common in the shallow waters near shore, although they were fairly abundant in deep water several miles offshore during warm months. Longley and Hildebrand (1941:5) stated that adults had not been observed at Tortugas.

Tarpon atlanticus (Cuvier and Valenciennes). Tarpon. None of these fish was taken during the investigation. Reliable sight records are at hand, however, to justify the listing of the species for the Cedar Key region. Individuals have been reported in the main ship channel at Cedar Key and caught in the Waccasassa River, approximately 13 miles east of Cedar Key, and in the Suwannee River to the north. The river observations were made during April and May, 1950.

Clupeidae

Harengula pensacolae pensacolae Goode and Bean. Pilchard, Razorbelly. Although abundant in the open water about Cedar Key during most of the year, only four specimens were taken in the trawl. These individuals, which ranged in size from 24 to 31 mm, were caught in November from a channel. The surface temperature was 20.8°C., and the salinity 22.8 ppt. The earliest seasonal record of *H. pensacolae pensacolae* during the investigation was in March. Specimens approximately 70 mm in length were taken from beneath the pier at night, when the temperature was 21.1°C., and the salinity was 30.4 ppt. Larger specimens of approximately 100 mm in length were captured from beneath the pier in August (mean temperature: 28.0°C.; salinity: 25.9 ppt.). At this time hundreds of the fish were seen vigorously darting about in compact schools and were being caught for bait by fishermen using an ingenious chain-like snare made of interlocking links of leader wire. When this was weighted and lowered into a school of pilchards, the fish became gilled in the links and were then brought out of the water. Large individuals were present in the area during the warm months and were not observed after November.

Food of *H. p. pensacolae* in the Cedar Key area consisted of various plankton crustaceans.

Gunter (1945:25) reported this species on the Texas coast under the name of *H. macropthalma* and stated that it is abundant in waters of high salinity (chiefly the Gulf beach) from April to November, with the greatest abundance being attained in the fall. Furthermore, he found post-larval young of the species twice during one summer and suggested that there are two spawning periods (or at least spawning peaks) per season. Longley and Hildebrand (1941:10-11) found *H. macrophthalma* to be common along shore and about the wharves at Tortugas during summer.

Rivas (1950:298), in a recent revision of the genus, stated that, so far is is known, *H. p. pensacolae* is the only species of *Harengula* inhabiting the Gulf coast of the United States.

Opisthonema oglinum (LeSueur). Thread Herring. This species was not recorded for Cedar Key during the period of investigation. However, on September 15, 1951, thousands of individuals were observed around the city pier, where they exhibited interesting behavior during a change of tide. The fish were not particularly conspicuous around the pier during the incoming tide. During the short time of dead high tide, several scattered schools became evident. As the tide began to ebb, the schools consolidated and massed parallel to the pier on the upcurrent side where their continual swirling at the surface

sounded like heavy rainfall. Occasionally a group of the fish would spring from the water, apparently eluding a predator.

Thirty-five specimens, 61 to 77 mm in length, were captured with a cast net. These fish were dull-greenish on the upper sides and silvery below. The longitudinal streaks formed by black spots on each scale were four in number on the upper sides. Posterior to a small, diffuse humeral spot, four or five smaller blotches followed the lower margin of the dorsal coloration to about midway the dorsal fin.

Although abundant at this particular time, this species was apparently of seasonal occurrence. Jordan and Gilbert (1882:247) reported two specimens for Pensacola and stated that the species did not appear to be very abundant. Gunter (1945) found the fish to be uncommon on the Texas coast, but stated that it might be expected both in summer and winter. Longley and Hildebrand (1941) did not record it for Tortugas.

Engraulidae

Anchoa mitchilli diaphana Hildebrand. Southern Bay Anchovy. Sixty-eight specimens were taken during the investigation. One was caught in the trawl on the flats in October, in approximately eight feet of water, when the temperature was 24.0°C. and the salinity 21.8 ppt. Forty-three individuals were collected off sandy beaches in June, October, December, and March. Three additional specimens were killed with rotenone on the flats in January, 1950.

A female anchovy, 52 mm in length, taken in June, was found to have mature ovaries. Kilby (1950:52) found young of 16 to 19 mm in length to be present in waters of shallow beach areas in June and October. Gunter (1945:35) attributed a long breeding season to the species, as did Hildebrand and Schroeder (1928:110) for *A. m. mitchilli.*

Stomach analyses revealed the food of the anchovy to be small crustaceans of the subclass Malacostraca. Hildebrand and Schroeder (*loc. cit.*) found that *Mysis* and copepods composed the principal diet of *A. m. mitchilli.*

From the collection data it appeared that anchovies were present throughout the year at Cedar Key. Kilby (*loc. cit.*) gave further evidence by recording anchovies taken in February, April, July, August, and November.

Field observations and experience indicated greater abundance of anchovies than is shown by the number of specimens taken in the trawl. That this species is common is shown by the 1,160 specimens taken in 17 collections by Kilby (*loc. cit.*), who used a minnow seine and investigated the beach areas more intensively than was possible in this study. Gunter (*op. cit.*, 34) caught 11,054 specimens in 109 trawl hauls during his work on the Texas coast and stated that the "species mass" in Texas waters was very large. Hildebrand and Schroeder (*loc. cit.*) noted that the northern form, *A. m. mitchilli*, was one of the most abundant species of fish in Chesapeake Bay and was present at all seasons.

INIOMI

Synodontidae

Synodus foetens (Linnaeus). Lizardfish. Forty-nine lizardfish were caught in 34 collections. Over 80 per cent of the specimens came from channels, sloping

edges of flats, deep flats, or other habitats in which the bottom was muddier than in the typical sandy, shallow flats with dense vegetation. This species is an able swimmer, however, and may be expected to graze over considerable area and through various habitats. Specimens ranging in size from 18 to 233 mm were collected where temperatures varied from 8.3° to 31.7°C., and in salinities which ranged from 17.5 to 31.5 ppt. Longley and Hildebrand (1941:22) stated that at Tortugas this species occurs in the deep channels within the lagoon and may be taken commonly on the sandy flats. Hildebrand and Schroeder (1928:131) described the habitat as sandy shores and the species as a bottom form.

The smallest fish were captured in July, 1950, and May, 1951. The July individuals were 18 and 27 mm in length, the latter fish having been taken in a nearly fresh condition from the stomach of a specimen of *Paralichthys albigutta*. The May specimen was 36 mm in length and was collected from a deep flat when the temperature was 28.0°C. and the salinity 23.9 ppt. The presence of small individuals in May and July indicated a spring spawning for the species. This breeding time agrees with that suggested by Kilby (1950:54), based on small fish taken in August in shallow waters along a beach at Cedar Key, and Gunter (1945:41), who took fish ranging from 37 to 41 mm in total length from Aransas Bay, Texas, in April. Length-frequency curves did not give significant information, although growth appeared to be rather rapid, since nine specimens taken in August ranged from 66 to 109 mm in length; in September, five examples, from 87 to 140 mm; and in October, ten individuals, from 64 to 183 mm.

Sixteen stomachs of *S. foetens* were examined for food. Of 11 which contained food, fishes were found in ten and peneid shrimp in two. Most of the fishes taken as food were in a stage of digestion too advanced to permit identification. Two species were identified, however, as *Ceratocanthus schoepfi* and *Anchoa mitchilli*. One lizardfish, 95 mm in length, had eaten five undetermined fishes, which ranged in size from 17 to 22 mm. Smith (1907:139) reported this species for the North Carolina coast and stated that it is a voracious feeder, the food consisting principally of small fish, but with crabs, shrimp, worms, and other animals also being eaten.

This species appears to be seasonally variable in abundance at different points within its known range. At Cedar Key it was found throughout the year, while Gunter (*loc. cit.*) reported no lizardfish taken in the winter on the coast of Texas. This fact is interesting, since water temperatures and salinities in winter in the two areas are similar, particularly in Aransas Bay which has, however, a slightly greater temperature range (Gunter, *op. cit.*, 125).

NEMATOGNATHI

Ariidae

Bagre marina (Mitchill). Gafftopsail Catfish. Although known to be common at Cedar Key from April through October, no specimens of this species were taken in the trawl during the investigation.

Adults with ripened gonads were abundant in April and May and were caught in considerable numbers on hook-and-line from the city pier. One

female, approximately 40 cm in length, caught in May, contained 42 well-developed eggs from 17 to 18 mm in diameter. Many authors have reported on the practice of oral gestation by this species.

Storey (1937:12) listed this species as one of the "fishes always hurt" by freezes at Sanibel Island, Florida. This high sensitivity to cold probably accounts for the absence of the fish in winter at Cedar Key.

Even though the catfish is seasonally abundant at Cedar Key, local fishermen ignore it. Thus, it is interesting to note that in Texas (Gunter, 1945:35) this species is used for food, an average of 11,510 pounds having been sold annually between 1935 and 1942.

Galeichthys felis (Linnaeus). Sea Catfish. Six specimens of this species were taken in three collections with the trawl. Two examples, 116 mm in length, were taken in an exploratory collection in June at night in Goose Cove over muddy sand bottom. The surface temperature was approximately 22.0°C.; the salinity was 30.0 ppt. Three individuals, measuring 82, 91, and 92 mm, were caught in November during the day from deep flats with sand and mud bottom east of North Key, near a channel. The temperature was 15.5°C., and the salinity 21.2 ppt.

As in the preceding species, oral gestation is characteristic of this fish, and breeding in the Cedar Key area apparently occurs in early summer, probably May and June. In Texas, breeding was found to be in June and early July, with the young being liberated in August (Gunter, 1945:40) and possibly late May (Gunter, 1947). Spawning in North Carolina takes place in the summer (Smith, 1907:64).

Food of young specimens of *G. felis* consisted mostly of various crustaceans. One of the 116 mm specimens had eaten copepods, shrimp, and amphipod crustaceans. Stomachs of the two larger November specimens contained hundreds of copepods and one shrimp each, while the 91 mm individual had eaten mysids, copepods, and polychaete worms. The adult sea catfish took crabs, shrimp, and fishes for good. Gunter (*loc. cit.*) found the blue crab and the mud shrimp (*Calianassa jamaicense louisianensis*) to be the chief items of food of sea catfish on the Texas coast.

Storey (1937:12) listed this species for Sanibel Island, Florida, where she found it to suffer high mortality during freezes. Smith (*op. cit.*: 63) recorded the sea cat for North Carolina beaches and stated that it was a bottom-loving fish, feeding chiefly on worms and small crustaceans, but readily eating fish, flesh, or fowl, dead or alive.

At Cedar Key, this species was more abundant than *Bagre marina*. Adult *G. felis* reached what appeared to be maximum abundance in May and June, although it was common throughout the remainder of the summer. The mean monthly temperature for May was 26.1°C., and salinity was 29.7 ppt.

APODES

Echelidae

Myrophis punctatus Lütken. Worm Eel. This species is represented by 31 specimens taken in three collections. Nine individuals were captured in February, 1949 (mean temperature: 16.6°C.), through the use of rotenone in

Deep Creek, near Cedar Key, by W. Dean Moody. These specimens ranged from 102 to 401 mm in length, with the mean at 192.3 mm. One specimen, 102 mm in length, was taken at night in a dip net from the pier in October when the mean monthly temperature was 23.3°C., and salinity 23.5 ppt. In December (temperature: 10.0°C.; salinity: 24.2 ppt.), 21 specimens were collected with a dip net from the same pier. These examples were apparently attracted to lights used by fishermen on the pier.

Stomachs which were examined contained small sand crabs.

Jordan and Gilbert (1882:261) reported this species at Galveston under the name of *Myrophis lumbricus sp. nov.* Ginsburg (1951:464) reported specimens from various localities on the northern Gulf coast and the Gulf west of Florida.

Ophichthidae

Ophichthus gomesi (Castelnau). Snake Eel.. Two specimens, 380 and 408 mm in total length, taken on hook-and-line from the pier at Cedar Key, are in the collection. Both eels were caught in July, when the mean temperature for the month was 28.9°C., and the salinity 27.8 ppt.

This species apparently ranges in southern coastal waters of the United States and southward. Ginsburg (1951:478) reported specimens from Charleston, Cape Canaveral, Key West, Gulf coast localities, Puerto Rico, and Rio de Janeiro. It was not reported by Longley and Hildebrand (1941) at Tortugas.

Muraenidae

Gymnothorax saxicola Jordan and Davis. Spotted Moray. The spotted moray is represented in the collection by two examples approximately 400 and 450 mm in total length. The smaller specimen was collected from the pier in September, 1950, when the temperature was 27.2°C., and the salinity 21.3 ppt. The larger individual was taken from a channel in October, 1949. The mean temperature for that month was 25.0°C., and the salinity 23.3 ppt.

Several individuals which were killed during a hurricane in September, 1950, were observed on the beach on September 7.

SYNENTOGNATHI

Belonidae

Strongylura notata (Poey). Needlefish. None of this species was taken in the trawl. Twenty-one specimens were taken in a seine while collecting in a shallow beach zone at Piney Point. These individuals, 75 to 125 mm in length, were caught in July, when the surface temperature was 30.0°C. and the salinity 26.7 ppt.

Stomach analyses of needlefish revealed various species of shrimps as the main item of food.

Cedar Key is apparently near the northern limits of the known Gulf distribution of this species although it has been recorded on the Texas coast (Gunter and Knapp, 1951:135). Longley and Hildebrand (1941:27) described the range as being from Florida to the West Indies.

Strongylura timucu (Walbaum). Needlefish, Timucu. Trawl collections at Cedar Key failed to catch specimens of this species. Fourteen individuals rang-

ing in size from 25 to 253 mm were collected in June in the shallow water of a beach station by means of a seine. The temperature of the water at the time of the collection was 28.3°C., and the salinity was 31.6 ppt. Three specimens, 94 to 121 mm in length, were taken at the same locality in July (temperature: 28.1°C.; salinity: 26.3 ppt.). Needlefishes, assumed to be this species, although specimens were not examined, were observed at the surface throughout the area during the warm months from April through September. These observations agree with the collecting data of Kilby (1950:59), who took the species from April through October in the shallow waters close to the open Gulf. Both this and the preceding species of needlefish were strongly attracted to lights at night during the summer months.

Little is known of the breeding habits of *S. timucu*. No breeding adults were observed during the investigation. The presence of the 25 mm individuals in June indicated a possibility of spring spawning, although the length of the breeding season was not determined.

Stomachs of four specimens, 102 to 153 mm in length, were examined. Two were found to contain fish remains, and two of the stomachs were empty.

Jordan and Swain (1884:231) recorded *Strongylura marinus* at Cedar Key and described it as abundant in the harbor. No specimens of needlefish taken during this investigation correspond with the characters given by Jordan and Evermann (1896:714) for *S. marinus*. In the Cedar Key specimens identified as *S. timucu*, the caudal peduncle is deeper than broad and agrees with specimens described in the Tortugas account (Longley and Hildebrand, 1941:28) in having the ventral fins inserted more than twice as far from base of pectorals as from origin of anal.

Since all literature consulted describes the northern extreme of the known distribution of this species as being the Florida Keys, the Cedar Key records apparently represent a considerable extension of the known range on the Gulf coast of Florida. Gunter and Knapp (1951:135) reported *S. marina* for the Texas coast.

Hemiramphidae

Hyporhamphus unifasciatus (Ranzani). Halfbeak, Ballyhoo. Halfbeaks were common about the Cedar Key area during the warm months of the year. The speed and evasiveness of the species prevented its being taken in the trawl or minnow seine. Specimens could be captured easily at night, however, when they were attracted to lights and remained rather immobile. The earliest collection during the year was made in March at night, when the water temperature was approximately 21.0°C., and salinity was 30.0 ppt. Of six specimens collected, five ranged from 117 to 131 mm, and one was 169 mm in length. Observations indicated that the species probably remained in the area until cold weather in November or December. Kilby (1950:57) recorded this species in three collections at Cedar Key. It was taken during May, June, and July, and individuals varied in size from 60 to 95 mm. Jordan and Swain (1884:230) described *H. unifasciatus* as abundant at Cedar Key in November.

Individuals with developing gonads were observed in March, indicating a spring spawning in this region. Hildebrand and Schroeder (1928:153) stated that spawning takes place during summer in Chesapeake Bay.

ANACANTHINI

Gadidae

Urophycis floridanus (Bean and Dresel). Gulf Hake. One hundred and seventy-one specimens of this codfish were taken from the flats and channels during the period from January through April. Thirty-one of these were collected at night in January. The relative abundance of *Urophycis* is demonstrated by the fact that in January, 1951, they constituted 21 per cent of the total catch, and in February, 10 per cent. These fish first appeared on the flats following a freeze which occurred early in December, 1950, when the water temperature was recorded near 9.0°C. Collections made April 5, 1951, produced three specimens, while subsequent spring collections failed to reveal hakes. The sizes of the fish taken during the fourth months ranged from 33 to 112 mm, with most of the specimens being from 41 to 61 mm in length. Length-frequencies are shown in Figure 6.

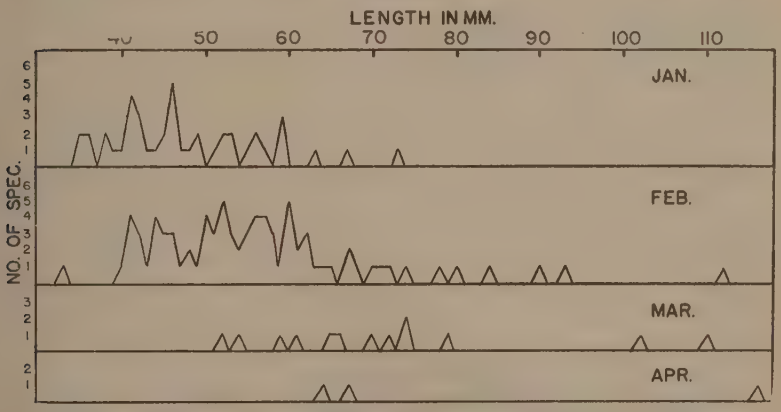


Figure 6. Standard Length-Frequency Data of *Urophycis floridanus*.

There appears to be a paucity of published information on the breeding habits of *U. floridanus*. There was no indication that this species spawns in the shallow waters at Cedar Key. The gonads failed to show any development, and it is probable that this species, like *U. chuss* and *U. regius*, spawns in deeper water.

Hakes proved to be voracious feeders; of 34 stomachs from specimens 41 to 107 mm in length, only two were empty. Usually the belly was noticeably enlarged by food items of large size. Shrimps were found in 100 per cent of the stomachs which contained food, while pinfish (*Lagodon rhomboides*) were contained in 44 per cent and amphipods in 35.2 per cent. Unidentified fish had been eaten by 17.6 per cent of the specimens examined, while copepods, crabs, and gastropods each occurred in less than six per cent of the stomachs.

The winter appearance of this species at Pensacola, Florida, has been noted by Jordan and Evermann (1898:2554) and on the Louisiana and Texas coasts

by Gunter (1945:47). Gunter found that on the coasts of both states *U. floridanus* appeared after a freeze and was most abundant during the winter months, although remaining until May. Although *U. floridanus* was not recorded, similar winter behavior of *Urophycis chuss* and *Urophycis regius* in Chesapeake Bay was observed by Hildebrand and Schroeder (1928:159-162).

Interesting spatial and temporal relationships were exhibited by this species during its occurrence in the area. It arrived following a severe cold spell which served to lessen the population density of larger piscivorous species. Shortly after the arrival of *U. floridanus*, young of *Lagodon rhomboides* appeared in prodigious numbers and were consumed in large quantities by the hakes. Small shrimps were also plentiful during this time. By the time the hakes left the shallow areas, the water had warmed to approximately 18.0°C.; the young shrimp and *Lagodon rhomboides*, which had been important items in the diet of the hakes, had grown to sizes which prevented their being eaten; and larger piscivorous fishes were appearing.

Additional evidence indicating that the migrations of hakes are in response to temperature changes was offered by H. F. Taylor (Coker, 1949:257), who found that cod and haddock albumen is coagulated at the temperature of the Gulf Stream (coagulation point 31°C.).

TABLE 2. MONTHLY CATCH DATA ON *Urophycis floridanus*

Month	*Number of Specimens*	*Temp. Range °C.*	*Salinity Range ppt.*
January	72	11.5-16.5	26.8-27.8
February	83	10.5-19.5	25.4-29.8
March	13	18.5-23.0	25.8-32.9
April	3	17.5-18.0	22.4-24.7

ACANTHOPTERYGII

SYNGNATHIDAE

Syngnathus scovelli (Evermann and Kendall). Southern Pipefish. Six hundred and thirty-seven specimens of the southern pipefish were caught in the trawl. There are records for every month. Although taken frequently from shallow flats and channels, this species appeared to be more abundant in the deeper waters on the sloping sides of shallow flats and in typical deep flats. Tolerance to somewhat wide fluctuations in temperature and salinity was indicated by the year-round presence of this species. Mean monthly temperatures ranged from 12.2°C. in December, to 28.9°C. in July, while the salinity varied from 19.9 ppt. in September to 30.0 ppt. in June.

The presence of male pipefish with developing embryos in their brood pouches and of gravid females in all months indicated continuous breeding. Gunter, however, reported (1945:48) a distinct breeding season for this species on the Texas coast, since egg-carrying males were observed only in June, August, and November.

In addition to the obvious brood pouch of breeding males, sexual dimorphism is conspicuous in this species. Adult females are marked with 15 to 18 vertical bars of silver on the trunk and are consistently larger than males. Measure-

ments of 64 males and 58 females taken in March were plotted; the curves indicated that a majority of the breeding males ranged from 85 to 103 mm in length, and the females varied between 99 and 118 mm in length.

Counts of embryos contained in the brood pouches of males generally increased with the size of the fish, although some inconsistencies were noted. Shorter males (76 to 85 mm in length) carried an average of approximately 36 embryos, while the pouches of pipefish larger than 85 mm contained an average of nearly 50 eggs or embryos. Two males, each 117 mm in length, caught in September, were examined. One individual was carrying 81 eggs arranged in four rows toward the anterior of the pouch, tapering to two rows in the posterior region. The eggs were developed to the stage of formation of the *"Disque huileux"* of Lereboullet (Gudger, 1905:470), and were one millimeter in diameter. The second pipefish contained 83 eggs arranged in the same fashion as in the preceding individual, and with embryos two millimeters long. In smaller males the eggs were usually arranged in two lateral rows of from 15 to 20 eggs each. In most instances, nearly all of the eggs or embryos appeared to be at about the same level of development, although frequently unfertilized eggs of opaque white color were present.

The numbers of eggs of one millimeter in diameter contained in the ovaries of female pipefish also increased with size of the fish. Small females up to 100 mm in length held an average of approximately 28 mature ova, while larger specimens averaged nearly 65 eggs per female. One female, 121 mm in length, had 143 mature eggs contained in the ovaries; one ovary was 22x4 mm in size.

No embryos more than 15 mm long were found in brood pouches. Several pouches were examined in which the young ranged from 11 to 15 mm; in these instances the yolk was almost completely consumed. Such evidence would seem to indicate that the young leave the brood pouch at approximately 15 mm in length.

Examination of 98 stomachs of *S. scovelli* revealed that various crustaceans were utilized most frequently and in greatest quantity for food. Copepods were the most prominent item in the diet, having been taken in all seasons and usually in considerable numbers. Numerous stomachs, each of which contained over a hundred of those microcrustaceans, were examined. Amphipods were also eaten the year around, and small shrimp were taken frequently. Gastropods (*Bittium* sp. and *Mitrella* sp.) occurred occasionally in stomachs. The contents of a single average stomach of an individual of this species would consist of: one small shrimp, four amphipods, and 30 to 40 copepods.

Longley and Hildebrand (1941) did not record *S. scovelli* at Tortugas. Herald (1942:133) delimited the range of the species as "Matanzas, Florida, to Corpus Christi, Texas."

Syngnathus louisianae (Günther). Louisiana Pipefish. Thirteen Louisiana pipefish, ranging in size from 97 to 256 mm, were caught in the trawl from various habitats during the summer and as late as December. None was taken in late winter or early spring. The lowest temperature at which this species occurred was 10.0°C. (in December); the highest was 31.1°C. (in July). It was found in salinities ranging from 18.3 ppt. in October to 33.8 ppt. in June.

No breeding males were found among the specimens, and the females showed little gonadal development.

Food of this species was found to be similar to that of *S. scovelli*, discussed previously.

Comparison of the total catch of examples of this species with that of the other two larger pipefishes, *S. scovelli* and *S. floridae*, indicates that *S. louisianae*, in relation to the other sygnathids, is relatively uncommon in the shallow waters about Cedar Key.

Herald (1942:133) defined the range of *S. louisianae* as extending from Maryland to Aransas Bay, Texas. This and previous investigations appear to indicate that this species is uncommon throughout much of its range. Gunter (1945:48) took four specimens in Aransas Bay; Longley and Hildebrand (1941:64) mentioned four specimens in their Tortugas collection; Smith (1907:171) found it in the same localities and at the same time as *S. floridae*, but less abundant; and Hildebrand and Schroeder (1928:184) stated that it undoubtedly is rare in Chesapeake Bay.

Syngnathus floridae (Jordan and Gilbert). Florida Pipefish. Three hundred and seven Florida pipefish were taken in the trawl. All months were represented. The species appeared to be slightly more common on deep flats or approaches to shallow flats where the bottom was somewhat muddy, although many individuals were taken from shallow, sandy-bottomed, grassy flats. The surface temperatures at which these pipefish were taken ranged from 10.0°C. in December to 30.6°C. in July; the salinities varied from 17.5 ppt. in Septemebr to 30.0 ppt. in June.

Breeding evidently occurs throughout the year in the Cedar Key area, although fewer ripe individuals were noted from November through January. Male pipefish with young in the brood pouch were caught in all months except December; the period of greatest abundance of pregnant males was July through October. The number of young or eggs contained in the brood pouch ranged from 130 to 447 in the larger individuals, for an overall average of 263.9 per fish. Pregnant males ranged from 116 mm in length (a specimen taken in April) to 176 mm. The average length of males examined was 149.0 mm. Gravid females, ranging in length from 137 to 194 mm (average: 167.3 mm), were present in all months except January and April. The smallest ripe female examined was 122 mm long and was caught in February. The number of matured ova in the gonads of female pipefish varied from approximately 140 in smaller individuals to approximately 1,100 in one specimen, 192 mm in length. The average number of developed eggs in the ovaries was found to be approximately 519 per fish. The length data agree essentially with Gudger's observations (1905:465) on the breeding habits and embryology of *S. floridae* at Beaufort, North Carolina. He found pregnant males to be 4.5 to 8.9 inches long, and females 3.0 to 8.4 inches long, the females being generally larger than males.

Food of 22 specimens taken at various seasons proved to be similar to that of *S. scovelli*, previously discussed. Shrimps were eaten at all seasons and occurred in 16 of 18 stomachs which contained food. Amphipods were found in four of the stomachs from specimens captured in summer and winter.

The treatment of this population of pipefish is made with reservations, insofar as the identification is concerned. It is possible that both *S. floridae* and *S. mackayi* occur in the vicinity, and Herald (1942:133) has stated that the meristic characters of the two are almost identical, the brood pouch being the best character; thus many females cannot be identified.

Microgнathus crinigerus Bean and Dresel. Pipefish. This diminutive pipefish is represented in the Cedar Key collection by 51 specimens ranging from 52 to 82 mm in length. Although much too small to be expected in a trawl catch, they were, nevertheless, taken in the trawl during seven months, throughout all seasons and from various habitats within the area.

Breeding males were noted in May, August, and September. A single male, taken in May, contained 26 embryos, ranging from 5.5 to 6.0 mm in length, encircling yolk of approximately one millimeter in diameter. The embryos with yolk were arranged in two rows running the length of the brood pouch.

Copepods and other microcrustaceans appeared to be the main items in the diet of this pipefish.

The range of this species as given by Herald (1942:134) extends from Miami, Florida, to Cameron, Louisiana.

Hippocampus hudsonius punctulatus Guichenot. Seahorse. This species is represented in the Cedar Key collection by 59 individuals. It was caught in all months except June and November. Seahorses ranging in size from 12 to 140 mm were taken from varied habitats, although predominantly from deeper areas and channels. The largest specimens (100 to 140 mm in length) were taken during the period from March through May, and in December. This species is apparently tolerant to wide ranges in both salinity and temperature. Being a year-round resident of the area, it was subjected to variations of 10.1 ppt. in salinity and 16.7°C. in temperature.

Small examples, ranging in size from 12 to 25 mm in length, were taken in February, April, August, and October. In view of the breeding habits of other species of syngnathid fishes, it appears likely that this species also breeds year-round in this area, although large males with distended brood pouches were noted only in December.

Food of Cedar Key specimens consisted mainly of shrimp and microcrustaceans.

Hippocampus regulus Ginsburg. Dwarf Seahorse. Thirty-two specimens of *H. regulus* were caught in all months except June, September, April, and May. Of those collected in the trawl, nearly 75 per cent were caught on deep flats and in an island cove; the remainder was captured over shallow flats.

Ginsburg (1937:584-594; 1952:101) has shown *H. regulus* and *H. zosterae* to be allopatric on the Gulf coast, with *H. zosterae* occurring on the west coast of Florida. Examinations of the Cedar Key population indicated that the local population agreed more closely with *H. regulus* than with *H. zosterae*, especially as regards dorsal ray counts. The counts of 20 specimens are shown as follows:

Location	*Numbers of fish showing each Dorsal Ray Count*		
	10 rays	*11 rays*	*12 rays*
H. regulus, Mississippi and Texas (Ginsburg, *op. cit.*, 589)	2	15	1
Cedar Key, Florida, population	2	15	3

Mr. Ginsburg has examined the Cedar Key specimens and agrees (personal communication) that the local population should be assigned to *H. regulus*.

CYPRINODONTES

Cyprinodontidae

Lucania parva (Baird and Girard). Rainwater Fish. Only three specimens of this small cyprinodont were taken in the trawl from the open water about Cedar Key. They measured 20, 25, and 28 mm in length and were collected in October, when the surface temperature was 24.0°C. and the salinity 21.8 ppt.

Exploratory collections and field observations have shown that cyprinodont fishes generally were found to be most common in shallow outer beach zones, or pools and water courses in the extensive Juncus marsh which borders the coastal shoreline in this region of the state. In their particular habitats these fishes were found usually to be abundant. A few individuals of various cyprinodont species were taken occasionally from the flats in open water during the present study and are listed below. Kilby (1950), in an extensive study of the marsh area at Cedar Key, obtained large numbers of these same fishes in addition to two species which were not found on the flats: *Fundulus confluentus confluentus* and *Adinia xenica*.

It will be seen that most of the cyprinodont specimens taken in the trawl or seines from the shallow flats were collected during the winter months. From November through February the low tides usually drained the marsh, leaving water only in scattered pools and deeper channels. It was then that at least some individuals of various populations moved out onto the flats. Temperature did not appear to be an important factor, since the species were found generally in the marsh when sufficient water was present.

Fundulus grandis grandis Baird and Girard. Gulf Killifish. In addition to specimens taken from beach zones, 33 individuals (41 to 75 mm in length) were collected in February from a near-shore flat at low tide. The temperature was 14.5°C. and the salinity 30.0 ppt. One specimen, 95 mm in length, was taken in the trawl on a deep flat in October, when the temperature was 24.0°C. and the salinity 21.8 ppt.

Three examples of the Gulf killifish, 59, 65, and 70 mm in length, were taken in a shallow water beach collection in July (temperature: 30.0°C.; salinity: 27.4 ppt.). Another beach collection in March, when the temperature was 23.5°C. and the salinity 32.4 ppt., yielded ten specimens, which ranged from 59 to 93 mm in length.

Fundulus similis (Baird and Girard). Longnose Killifish. This species was

not taken in the trawl from the open waters, although two collections made by means of a seine along a shallow beach zone contained 51 individuals. A July collection, made when the temperature of the water was 30.0°C. and the salinity 27.4 ppt., contained 34 specimens ranging from 21 to 80 mm in length (mean: 32.7 mm). Seventeen specimens taken in March (temperature: 23.5°C.; salinity: 32.4 ppt.) ranged from 47 to 107 mm in length, with a mean of 73.3 mm. A few examples of this species were collected in the push net from shallow flats near islands in November and February.

Floridichthys carpio carpio (Günther). Florida Goldspotted Killifish. Four specimens (the greatest number of any one species of cyprinodont fishes) were taken in the trawl from the open water areas. The individuals ranged in size from one 18 mm specimen taken in July (temperature: 29.0°C.; salinity: 27.8 ppt.) to three examples of 42, 42, and 45 mm collected in December (temperature: 13.0°C.; salinity: 26.4 ppt.) and in February when the surface temperature was 11.5°C. and the salinity was 26.1 ppt. Four specimens, 31 to 41 mm in length, were seined from a shallow flat at low tide in February.

Additional specimens taken by means of a push net at low tide from flats near shores of islands are in the collection. They were taken during November, December, January, and February, the previously mentioned season of extremely low tides, when the marsh areas were drained.

Cyprinodon variegatus variegatus Lacépède. Southern Sheepshead Killifish. No examples of this species were collected in the trawl during the investigation. These fish are only taken in trawls, i.e., away from shore, during cold spells (Gunter, 1945). Specimens were taken during low tides by means of seine and push nets from shallow flats near islands in November, January and February. Mean monthly temperatures and salinities for those months are shown in Figures 2 and 4.

Kilby (1950:81) collected 4,747 specimens in the marsh at Cedar Key, and length-frequency curves suggested year-round breeding activity. In two different investigations Gunter (1945, 1950) found that the young first appeared in Texas in June and July.

Food found in stomachs of specimens consisted mainly of algae and organic detritus.

Poeciliidae

Mollienesia latipinna LeSueur. Sailfin. None of these fish was taken in the trawl from the open water areas about Cedar Key. Many were observed on shallow flats near shore and in each pools at low tide. Kilby (1950:87) found *M. latipinna* abundant in the marsh areas, where he took 10,846 specimens in 93 collections. The scarcity of the species in the open water, together with Kilby's data for marshes, indicate that sailfins characteristically live in sheltered habitats. Gunter (1945:46) took but one specimen from the open waters on the Texas bays from March, 1941, to November, 1942.

PERCOMORPHI

Atherinidae

Menidia beryllina (Cope). Silversides, Glassminnow. Two hundred and

seventy-one examples of this species were taken in eight exploratory collections made by means of a minnow seine in shallow beach areas. The specimens ranged in size from 20 to 93 mm. None of these fish was caught in the trawl. Although common in the open waters of the area, they appeared to associate themselves usually with some sort of shelter, such as islands, piers, oyster bars, or pools containing rubbish. The species is a fast-swimming surface form and adept at dodging almost any collecting device except an encircling seine. Large schools were repeatedly observed underneath the city pier at Cedar Key. It was impossible to capture specimens, for, as soon as a cast net was thrown, or one thrust made with a dip net, the fish retreated to a point just out of reach and stayed until danger had passed. They were caught, however, with some facility in a dip net at night when attracted to light.

Breeding fish were captured in March and in July, with the smallest individuals (20 to 22 mm in length) being taken in June and July. An extended breeding season was indicated by observations of small specimens in shallow beach zones during spring and summer, and by the presence of the fish with ripened gonads. Gunter (1945:49) found specimens of this species on the Texas coast to contain developing and mature gonads from February to August and suggested that there might be two spawning peaks per season, one in the spring and one in late summer. Hildebrand and Schroeder (1928:191) indicated a protracted breeding season and also mentioned the possibility that the fish spawns more than once during a season.

The food of *M. beryllina* in the Cedar Key area was found to consist mainly of plankton organisms, such as copepods, and some algae. Amphipods had been eaten by some of the specimens examined. Six stomachs of fish taken at night when attracted to a light contained freshly ingested insects, which also had doubtless been attracted to the light. Hildebrand and Schroeder (*loc. cit.*) found the food of this species to consist of small crustaceans, small mollusks, insects, worms, and algae.

Membras martinica vagrans (Goode and Bean). Rough Silversides. One hundred and eighty specimens of this atherinid were collected during the investigation. None was caught in the trawl, although the species was common along the sandy beaches in shallow water and in open water where it schooled near the surface. It was most abundant during summer months, when it congregated around docks and pilings. It appeared to be strongly attracted to light at night, when specimens were collected easily with a dip net. Eighty-one specimens, 23 to 59 mm in length, were taken at night under a light in October, when the water temperature was approximately 22.5°C., and the salinity was 20.5 ppt. Seventy-eight individuals, 36 to 75 mm in length, were caught in the same manner in March, with the surface temperature near 21.0°C. and the salinity 30.4 ppt. These two collections were made from the surface in water 10 to 12 feet deep. Another collection was made with a seine in a shallow beach zone in March (temperature: 23.5°C.; salinity: 32.4 ppt.), when 21 specimens from 32 to 59 mm long were taken. Gunter (1945:50) showed that this fish was most abundant in the freshest water and in water of high salinity, with fewer fish caught at an intermediate salinity range, and that the largest fish were only found in the saltier water.

The March collection contained females ranging in length from 65 to 75 mm, with mature ova in the gonads. Gunter (*loc. cit.*) took ripe males and females from 63 to 85 mm in length during March and April along the Texas coast; young appeared as late as October. Hildebrand and Schroeder (1928:192) noted that Chesapeake Bay spawning appeared to be a protracted one, since specimens with distended gonads were captured from May through August.

Stomachs of individuals 40 to 59 mm long, taken in October, and others 65 to 78 mm in length, collected in March, were examined. The food was found to consist almost wholly of copepods, except for a few freshly ingested insects.

This fish was not observed or taken during the winter months. Kilby (1950:103) recorded it off Cedar Key beaches from April through October. Gunter (*loc. cit.*) failed to take rough silversides in December and January on the Texas coast, and Hildebrand and Schroeder (*loc. cit.*) did not find the species present in Chesapeake Bay in winter.

Mugilidae

Mugil cephalus Linnaeus. Striped Mullet. Although known to be abundant in the shallow waters about Cedar Key, none of this species was collected in the trawl during the investigation.

Young individuals, ranging in length from 22 to 39 mm, were caught with a seine from January through March in shallow waters of sandy beaches. Adults with matured gonads were observed from November, 1950, through February, 1951. Kilby (1949:19) reported young striped mullet in the Cedar Key area from October through June and stated that rate of growth permitted October specimens of approximately 18 mm in length to reach about 65 mm by mid-April.

Kilby (1950:101-103) recorded two other species of mullet (*Mugil curema* Cuvier and Valenciennes and *Mugil trichodon* Poey) not taken during the present investigation. He took *M. curema* in the spring and early summer and *M. trichodon* in midsummer, both in small numbers. The young occurred in mud-bottomed tide pools.

Sphyraenidae

Sphyraena picudilla Poey. Barracuda. One specimen, 61 mm long, was taken in a beam trawl from a shallow grassy flat in May, 1950. The mean monthly surface temperature was 26.1°C.; the salinity was 29.7 ppt.

The identification of this specimen is based on the characters given by Longley and Hildebrand (1941:70).

As far as can be ascertained, large barracudas are rare in the shallow waters about Cedar Key, although they are occasionally seen in the deeper areas several miles offshore. These larger forms are probably referable to *S. barracuda.*

Sphyraena barracuda (Walbaum). Great Barracuda. A single specimen, 40 mm in length, was taken in a beam trawl in October, 1948, from a shallow flat near Seahorse Island.

This individual is provisionally identified as *S. barracuda* on the basis of characters given by Longley and Hildebrand (1941:70). The spinous dorsal

of the specimen is inserted posterior to the insertions of the pelvic fins and on a vertical line with the tips of the pectorals. The pelvics are inserted posterior to the insertion of the pectorals approximately mid-way the length of the pectorals. In the specimen identified as *S. picudilla,* the dorsal is inserted on a vertical line with the insertions of the pelvics and about three-fourths the eye diameter behind the tips of the pectorals. The pelvic fins in *S. picudilla* are inserted a distance equal to about one-half the diameter of the eye posterior to the tips of the pectorals. Although the sides of the specimen of *S. barracuda* are somewhat mutilated, there are fewer than 100 scales in the lateral line.

Scombridae

Scomberomorus maculatus (Mitchill). Spanish Mackerel. None of this species was caught in the trawl or seines during the investigation. Specimens were caught on hook-and-line from shallow waters about Cedar Key as early as March (1950) and as late as November (1951). Throughout most of the spring and summer the fish appeared to be scattered, while in late fall a schooling behavior was noted, apparently prior to leaving the area, since the species was not common during the coldest weather.

No young were caught, although commercial fishermen claimed that mackerel caught in the spring had well developed roe. Hildebrand and Schroeder (1928:203-204) found that the spawning period occurs in Chesapeake Bay during late spring and early summer.

Seasonal migrations are apparently characteristic of this species. Gunter (1945:55) stated that the Spanish mackerel is not caught on the Texas coast from November through March in most years and that it is taken in greatest abundance in August. Longley and Hildebrand (1941:71) found *S. maculatus* to be abundant in the vicinity of Key West only from about November to April and stated that it is caught occasionally in summer trolling at Tortugas. Hildebrand and Schroeder (*loc. cit.*) wrote that Spanish mackerel congregate in schools and seem to be migratory in their habits, appearing off the Middle Atlantic States in spring and fall runs, the first presumably representing a northward migration and the latter a southward one. However, no such runs of Spanish mackerel appear to take place within Chesapeake Bay, where the fish usually arrive in May or June and are present continuously until about September.

Carangidae

Caranx crysos (Mitchill). Blue Runner. None of this species was caught during the course of the investigation. Dr. E. L. Pierce, of the University of Florida, supplied sight records of the runner, and it is taken occasionally by commercial fishermen.

Caranx hippos (Linnaeus). Crevalle. Crevalle were found to be the most common of the larger carangid fishes in the shallow areas about Cedar Key. Although none was taken in the trawl or minnow seines, many were caught by sports fishermen from the city pier and occurred frequently in the net catches of commercial fishermen. Specimens were observed throughout the year except from December through February; the individuals in April and May were approximately 20 mm long, while those taken later in the year were generally larger (300 to 400 mm).

No evidence of breeding was found in adults examined, and no young were observed. Gunter (1945:57) found that young fish, 30 to 42 mm in total length, first appeared on the Texas Gulf beach in June.

The food of large crevalle in the Cedar Key area was found to consist primarily of fishes. Sea robins (*Prionotus scitulus latifrons*) and some unidentified forms were contained in stomachs from specimens caught in August.

Seasonal occurrence of this species has been noted in other localities within its range. Hildebrand and Schroeder (1928:222) stated that *C. hippos* usually appears in Chesapeake Bay in July or August. Gunter (*loc. cit.*) found crevalle in the Gulf off the Texas coast from April through November and cited an earlier work (Gunter, 1938) wherein he reported the species on the Louisiana coast from July to November. Longley and Hildebrand (1941:79) stated that it may be assumed that *C. hippos* is rare at Tortugas.

Selene vomer (Linnaeus). Lookdown, Moonfish. One specimen, 33 mm in length, of this carangid was collected. It was caught from the edge of a channel near Seahorse Island in September. The surface temperature and salinity at the time were 27.2°C. and 17.5 ppt., respectively.

At this size the filamentous dorsal spines and pelvic rays are most conspicuous. The black filaments of the second and third dorsal spines measured 74 mm in length, or over twice the standard length. The pelvic fins, being 23 mm in length, reached past the hypural. The dorsal count was VIII-I, 22; and the anal II-I, 18, depth 1.11.

Chloroscombrus chrysurus (Linnaeus). Bumper, Yellowtail. Seventeen examples, ranging from 30 to 47 mm in length, were taken during the month of October. One specimen, 30 mm long, was taken in the trawl from shallow flats south of Atsena Otie Key, and another, 41 mm in length, was taken the same day from the shallow waters off the beach on the east shore of Atsena Otie Key. The temperature of the water was 24.0°C., and the salinity was 21.8 ppt. Fifteen individuals, 32 to 47 mm in length, were collected in a dip net at night by lantern light from the surface of the water under the city pier at Cedar Key. The temperature at that time was near 23.0°C., and the salinity was 22.0 ppt. Large individuals, 150 mm in length, were common about piers in late summer and fall.

Kilby (1950:117) recorded six specimens taken in one collection from a shallow beach at Cedar Key in October. Gunter (1945:59) found the fish to be present in Louisiana and Texas only in summer and fall and took one shedding female and three ripe males in August, 1941. Hildebrand and Schroeder (1928:220) did not note bumpers during their investigation and indicated that only one specimen has been recorded from Chesapeake Bay. Smith (1907:211) stated that "while the bumper is found from Cape Cod to Brazil, it is not common north of Charleston and has rarely been taken in North Carolina waters."

One of the specimens listed above, taken from the shallow beach zone at Atsena Otie, was collected while it was swimming with a jellyfish. The same behavior was noted by Smith (*loc. cit.*) in describing a specimen taken "from the bell-cavity of a medusa (Dactylometra)." Longley and Hildebrand (1941:

76) reported four specimens, 10 to 17 mm in length, which were found swimming with the jellyfish *Aurelia*.

Trachinotus falcatus (Linnaeus). Round Pompano. This species was not observed during the period of the present investigation. Kilby (1950:118) caught one specimen, 43 mm in length, from a shell-and-mud-bottomed area, in October, 1948.

Hildebrand and Schroeder (1928:239) commented on the rarity of *T. falcatus* in the Chesapeake Bay area, and Baughman (1950b:246) cited a previous paper by him (1941) which indicated that this species is at least not common in the Texas waters. Thus it appears that the species is rare throughout its known range.

Trachinotus carolinus (Linnaeus). Common Pompano. Pompanos were not collected during the present investigation. Specimens occurred from April through November, 1951, in commercial fish houses. Most of the commercial catches were made from deep waters offshore, although individuals were caught occasionally from inshore areas. Fishermen stated that the species was "a weather fish," indicating that, although it was more common in summer and fall, it would enter the inshore waters whenever warm spells occurred during winter.

No evidence of breeding in the Cedar Key area was found. It was noted that the fish caught in the spring were rather emaciated, while those taken in fall usually contained more fat and were firmer in texture; these conditions may indicate an early spring spawning. Gunter (1945:60) found small fish, ranging from 13 to 15 mm in total length, to be present on the Texas Gulf beach from June through August or September and suggested an extended breeding season for the species.

Winter immigrations of this species have been reported for Chesapeake Bay by Hildebrand and Schroeder (1928:230), and for Texas by Gunter (1945:59-60).

Oligoplites saurus (Bloch and Schneider). Leatherjacket. None of these fish was caught in the trawl. One individual, 19 mm in length, was collected with a seine from the shallow waters of a beach zone in June (temperature: 28.3°C.; salinity: 31.6 ppt.). Two specimens, 77 and 80 mm in length, were taken with a dip net at night from beneath the city pier in August, 1951; another of the same size range was taken by means of a cast net thrown from the pier into a school of thread herring (*Opisthonema oglinum*) in September, 1951.

This species is apparently a summer and fall inhabitant of the shallow waters about Cedar Key and apparently not abundant. Kilby (1950:118-119) took 73 specimens in 12 collections from shallows at Cedar Key from June through October, and Jordan and Swain (1884:231) recorded one specimen taken with a seine in November, 1883. Gunter (1945:60) reported nine specimens taken in August and November during two years of work on the Texas coast. Jordan and Gilbert (1882:270) found the fish to be "rather common in summer at Pensacola." Longley and Hildebrand (1941:83) stated that the species is apparently rare at Tortugas and also at Key West.

Pomatomidae

Pomatomus saltatrix (Linnaeus). Bluefish. None of this species was taken in regular collections during the course of the investigation. It was found to be a seasonal inhabitant of the Cedar Key waters, however, and occurred in relatively large numbers in the deeper regions offshore. Individuals approximately 300 mm in length were taken occasionally from inshore waters during spring and summer. The species was not common during the coldest months (December through February).

Nothing was determined of the breeding habits of this species at Cedar Key, although commercial fishermen claimed that fish taken in October contained roe. Smith (1907:216) stated that the bluefish spawns offshore in summer, but ripe examples have rarely been observed, and nothing definite is known as to the spawning time and habits. He stated that young, three to six inches long, are abundant in Beaufort Harbor, North Carolina, in summer.

Gunter (1945:61) caught only one specimen of bluefish during his investigation on the Texas coast and stated that the species is uncommon there. Jordan and Gilbert (1882:272) found *P. saltatrix* to be rather common about Pensacola and rare or unknown at Galveston. Gunter (personal communication) stated that bluefish are fairly common at Biloxi, Mississippi.

Rachycentridae

Rachycentron canadus (Linnaeus). Cobia, Cabio. This species is known to inhabit the flats at Cedar Key from May through August. Large individuals were observed around channel markers and are frequently taken by sports fishermen. Baughman (1950b:246) pointed out the habit of the cobia of associating with various animate and inanimate objects, such as sharks, turtles, pilings, and drifting debris.

Two specimens, taken in August, 1950, when the water temperature was 28.9°C. and the salinity 24.6 ppt., were examined. One of these had eaten a cowfish, *Lactophrys tricornis,* and three catfish of undetermined species. The weights of the specimens examined were 30 and 15 pounds, which appear to be approximately the range of most of the cobia observed in the area.

Serranidae

Epinephelus morio (Cuvier and Valenciennes). Red Grouper. Jordan and Swain (1884:330) reported this species for Cedar Key and stated that it is common in deep water, being taken with hook-and-line on the snapper banks. None was observed during the present study of the inshore area, although the presence of the species on the banks was confirmed by commercial fishermen, and Dr. C. J. Goin, University of Florida, tells me of the fish in rocky areas approximately five miles offshore.

Longley and Hildebrand (1941:96) found red grouper to be common in the shallow waters about Tortugas, the young being particularly common wherever shelter was available.

Centropristes melanus Ginsburg. Blackfish. Two hundred and fifteen specimens of this serranid were taken in the trawl throughout the year, except January and April. Generally, blackfish were found to be more abundant on

the deeper flats and in channels and edges of channels where the bottom was mostly muddy sand, and especially where rock and shell were predominant. Nearly 80 per cent of the specimens were taken in such habitats. In the summer, young fish congregated around rock piles in shallow water and were easily observed in the clear water. Seasonally, the fish were most abundant during summer through late fall. Nearly 75 per cent of the examples were caught from June through November. The average mean surface temperature during those months was 25.3°C., with the mean monthly temperatures ranging from 28.9°C. (July) to 17.2°C. (November). The temperature in early November dropped to around 15.0°C., and by the end of that month the temperature was 7.8°C. Mean salinities during the months from June through November ranged from 23.0 to 30.0 ppt., except in September, when dilution from hurricane rains resulted in a mean monthly salinity of 19.9 ppt.

Only 19 individuals were captured in the trawl from December through May, and all except the May specimens were caught in channels or on deep flats. Mean monthly surface temperatures during that period varied from 12.2°C. in December to 24.5°C. in May, the average temperature being 17.3°C. The salinity range was slight (23.3 to 28.1 ppt.).

No blackfish with ripe gonads were observed during the year, since most of the specimens caught were young. Adults reach a length of 18 inches and attain about 3 pounds in size. The presence of small individuals, 22 to 25 mm in length, in May and June would seem to indicate a single late winter or early spring spawning season, followed by rather rapid growth (Figure 7). Smith (1907:281) stated that spawning occurs in spring off the North Carolina coast, probably in May. Hildebrand and Schroeder (1928:252) reported that spawning occurs probably late in May near the mouth of the Chesapeake,

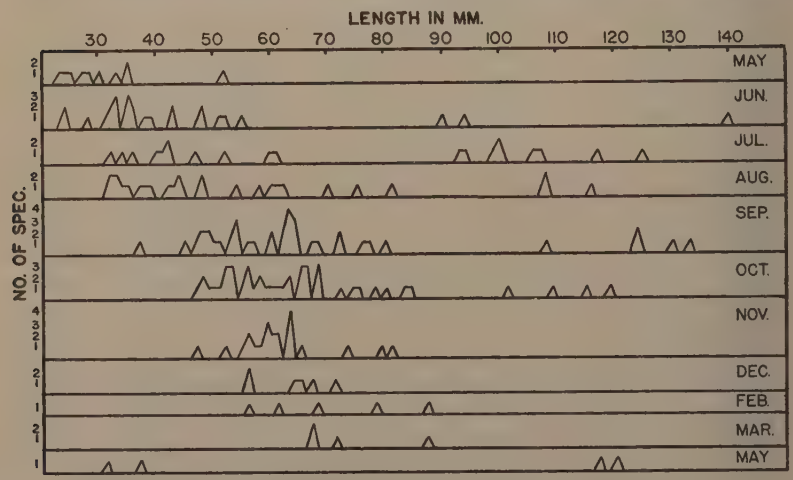


FIGURE 7. Standard Length-Frequency Data of *Centropristes melanus*.

and from the middle of May until the end of June off the New Jersey, Long Island, and southern New England coasts.

Thirty-eight stomachs were examined, of which seven were empty. Various shrimps, mostly carid and peneid species, were found in 29 of the 31 stomachs which contained food organisms. Some of the fish had as many as 15 shrimps in their stomachs, the average number being 3.75 per fish. What appeared to be xanthid species of small crabs were eaten by 17 of the blackfish, although one spider crab had been taken. The average number of crabs per stomach was 1.52. Fishes were ingested by five of the blackfish; among these were one *Synodus foetens,* 46 mm in length, which had been eaten by a blackfish 140 mm in length; three *Bairdiella chrysura;* one *Eucinostomus gula;* and one unidentified fish. Amphipods were found in one stomach. Hildebrand and Schroeder (*loc. cit.*) found the food of this species to consist of crustaceans, fish, mollusks, and plants.

Serraniculus pumilio Ginsburg. Four specimens of this species were taken in the trawl from the channels which cut through the flats at Cedar Key. The specimens ranged in size from 32 mm to approximately 40 mm. The smallest specimen was captured in July, one individual, 36 mm in length, was taken in October, and two fish, approximately 40 mm in length, were caught in December.

Diplectrum formosus (Linnaeus). Sand Perch. A total of 29 specimens of this species was captured during the investigation. Twenty fish were caught in regular trawl collections in June, July, September, October and November, while nine examples were taken in October and December in exploratory hauls. Of the total catch, approximately 80 per cent of the fish were collected from channels and deep flats; the remainder was caught on typical shallow flats. The average mean surface temperature during the season when sand perch were caught was 23.5°C., and the salinity 25.2 ppt. The individuals ranged in size from 29 to 110 mm, with the small fish, 29 to 39 mm in length, having been collected in June. The largest number of specimens in a single collection was caught in September when the surface temperature and salinity were 27.1°C. and 17.5 ppt., respectively. This lowered salinity occurred after a severe hurricane early in the month.

An immature sand perch, 17 mm long, was caught in May, 1950, and three specimens, ranging from 29 to 39 mm in length, were taken in June of the same year. This may indicate that spawning takes place in early spring, although the extent of the breeding season was not determined. None of the fish caught showed signs of gonadal development. Longley and Hildebrand (1941:104), in discussing the species at Tortugas, stated:

> The species does not breed at Tortugas during the summer, as even in late August the gonads are still small, but all of one type, having the appearance of ovaries. In view of the normal hermaphroditism of *Diplectrum bivittatum,* this is sufficient indication that the same condition prevails here.

Ten specimens, 70 to 110 mm in length, taken during the fall, were examined for food. The bulk of the stomach contents consisted of carid and

palaemonid shrimps, and mysids. Stomachs from examples taken in October contained mostly penecid shrimp; one sand perch 83 mm long had eaten a shrimp approximately 30 mm long. Copepods were found in one gut, and one unidentified fish in another. Longley and Hildebrand (*loc. cit.*) found the food of Tortugas sand perch to be composed largely of crabs and shrimps.

Dules subligarius (Cope). Sandfish. This species is represented in the Cedar Key collection by two specimens, 35 and 48 mm in length, caught between Seahorse Island and Snake Key by W. D. Moody in October, 1948. The mean temperature of the water during that month was 22.2°C., and the mean salinity was 26.1 ppt.

The following counts and color notes were made: Two individuals; D. X, 13; A. III, 7; gill rakers 7; branchiostegals 6; scales 6-about 44-14. The color pattern (formalin preservation, 3 years) agrees generally with the description given by Longley and Hildebrand (1941:107-108) of a Tortugas specimens, 31 mm in length. In the Cedar Key examples, the head coloration appears more as brown and cream reticulation than as stripes. The seven brown bands described by Longley and Hildebrand (*loc. cit.*) are more distinct in the younger individual. In the 48 mm specimen the brown is almost continuous, at least on the side, to the level of the origin of the soft dorsal. In both individuals the fourth and fifth narrow, creamy interspaces converge on the lower sides at the level of the third anal ray. Dorsally, the two interspaces are divergent and continue onto the dorsal fin, where they form an encircling margin of a dark basal spot between the tenth dorsal spine and eighth dorsal ray (sixth, in the smaller specimen). All of the fins except the pelvics are marked with distinct rows of dots, which give a banded appearance. The membrane between each dorsal spine is edged with black. The venter is uniformly creamy from isthmus to vent, with the light color spreading upwards on the sides, the spread beginning approximately midway between the pelvic fins and the vent and continuing to the vent.

Baughman (1950b:249) gave records of this species for the Texas coast. Smith (1907:283) mentioned collections of *D. subligarius* in shallow water and also from a depth of 13.5 fathoms off the coast of North Carolina.

Mycteroperca microlepis (Goode and Bean). Gag. Nine gags, ranging from 25 to 153 mm in length, were caught between May and August, 1950. Mean surface temperatures for that period ranged from 26.1°C. for May, to 28.3°C. in August. The salinity varied from 29.7 ppt. in May to 30.0 ppt. in June, and then dropped to 25.9 ppt. in August. The two smallest specimens (25 and 49 mm in length) were collected during May from a shallow, grassy flat northeast of Atsena Otie Key. The seven remaining individuals were taken from moderately deep flats and channel edges, with the three largest having been caught in a single trawl haul near the channel at the northeast tip of Seahorse Island.

An early spring breeding was indicated by the presence of specimens 26 mm long on the flats in May.

The stomach of a 71 mm individual taken in July contained five penecid shrimp, while another specimen, 100 mm long, taken the same month, had

eaten two peneid shrimp and one unidentifiable fish. Of the specimens taken in August (141 to 153 mm in length), one stomach was empty, and two contained six shrimp each.

Baughman (1950b:248) cited Texas records of *M. microlepis*. Gunter (1945) did not record it during his investigation of the Texas coast. Jordan and Gilbert (1882:273) found the species at Pensacola. Longley and Hildebrand (1941:100) noted that only four entries concerning the species were found in Dr. Longley's notes and indicated that it did not occur regularly in shallow water about Tortugas. Smith (1907:278) reported various collections of *M. microlepis* for Beaufort, North Carolina, and vicinity.

Lobotes surinamensis (Bloch). Tripletail. None of this species was taken during the present investigation. The fish is caught occasionally by commercial fishermen, and R. Kirk Strawn reported seeing one at night underneath a light on the city pier during the summer of 1950.

Although distributed widely (Cape Cod to Uruguay, Mediterranean Sea, and Japan), this species is apparently uncommon in the shallow waters of the Cedar Key region. Gunter (1945:61) likewise found the tripletail uncommon but not rare on the Texas coast, and Smith (1907:284) stated that it was not common anywhere.

Lutjanidae

Lutjanus griseus (Linnaeus). Gray Snapper, Mangrove Snapper. Twelve examples of the gray snapper were taken during late summer and fall. Four additional specimens in collections made prior to the period of investigation were also examined. All of the individuals were young fish, ranging in size from 19 to 62 mm in length, and were collected from August through November during which time the most decided drop in surface temperature took place. Figure 5 shows that the mean surface temperature dropped from 28.3°C. in August to 17.2°C. in November, 1950. At the same time, the mean salinity varied from 25.9 ppt. in August to 19.9 ppt. in September (due to a hurricane), and to 25.0 ppt. in November. Most of the snappers were taken from shallow, grassy flats; none came from channels or from off sandy beaches.

Three stomachs from the September individuals contained 13 peneid shrimp and some organic detritus. Interesting experiments in the feeding behavior of *L. griseus* at Tortugas were described by Longley and Hildebrand (1941:116), who found that the natural food of this species consisted of crabs, shrimp, squid, and annelids.

Lutjanus aya (Bloch). Red Snapper. This species was recorded under the name of *L. campechianus* (Poey) for Cedar Key by Jordan and Swain (1884:232) with no annotation. It was not seen during the present investigation.

Jordan and Gilbert (1882:275) recorded *L. blackfordi* for Pensacola, where it was found on the snapper banks from five to thirty miles offshore.

Rivas (1949:15) stated that *L. aya, L. campechanus,* and *L. blackfordi* all refer to the same fish, with *L. aya* having priority.

It is likely, then, that the specimens reported by Jordan and Swain (*loc. cit.*)

for Cedar Key were obtained from banks several miles offshore and that the red snapper should not be expected in the inshore waters.

Lutjanus synagris (Linnaeus). Lane Snapper. Thirty-two specimens of this species were caught in the trawl during the months of August, September, October, and November. The individuals were young (21 to 86 mm in length) and were collected only from deep and shallow flats. The temperatures at which specimens were captured ranged from 28.9°C. in August to 15.5°C. in early November; a cold spell in late November resulted in surface temperatures of around 8.0°C. The average monthly mean temperature for the period when specimens were caught was 25.9°C. Mean monthly salinities varied from 19.9 ppt. (September) to 25.9 ppt. (August). So far as can be determined, adult lane snappers do not inhabit the shallow waters about Cedar Key.

Apparently, little is known concerning the breeding habits of this species. Young individuals, 21 to 22 mm in length, were taken at Cedar Key in August and again in October, perhaps indicating a late spring or early summer breeding season. Spawning evidently takes place some distance offshore.

Crustaceans appeared to be the main constituent of the diet of young lane snappers. Of nine stomachs which contained food, various species of carid and peneid shrimps occurred in eight, for an average of 2.5 shrimps per stomach. One individual had eaten nine mysids, and copepods were found in two stomachs. Fish had been ingested by two snappers, 67 and 48 mm in length.

References to *L. synagris* generally define the northern limit of its range as South Florida or the Florida Keys. Storey (1937:15) gave Tampa, Florida, as the northern limit; thus the Cedar Key record in this study apparently extends the range, at least on the Gulf coast of Florida. Baughman (1950b:250) listed the species for the Texas coast.

Haemulidae

Haemulon plumieri (Lacépède). Common Grunt. A total of 27 grunts was collected from July through November. Sixteen specimens, ranging from 33 to 59 mm in length, were taken in the trawl from September through November. In addition, larger individuals, nearly 100 mm in length, were caught with hook-and-line from the city pier during August, when the mean monthly surface temperature was 28.3°C. and the salinity 25.9 ppt. During the period when the young were captured in the trawl, the mean temperature declined from 26.1°C. in September to 17.2°C. in November, while the salinity increased from a mean of 19.9 ppt. (September) to 25.9 ppt. (November). All except one of the grunts were collected from moderately deep flats with muddy sand bottom. The remaining individual was taken from a shallow, sand-bottomed flat near Grassy Key. Grunts were apparently fairly common during these fall months, as nine specimens were collected in a few short hauls with the trawl at one locality in October. Eleven specimens were collected at low tide on shallow flats from July through October. They ranged from 24 to 59 mm in length. Temperature and salinity means for July and August were, respectively, approximately 28.5°C. and 26.0 ppt. Six small specimens, ranging from 39 to 53 mm in length, were captured on grassy flats during October and November, 1949. Conditions of water tem-

perature and salinity during this period were essentially the same as noted for 1950.

The presence of immature grunts for this limited period seemed to indicate a spring spawning, with, perhaps, an early migration to deeper water.

Six stomachs of these specimens contained crustaceans such as copepods and mysids as the main items of food.

Jordan and Swain (1884:232) found *H. plumieri* to be uncommon at Cedar Key in November, 1883. Storey (1937:17) stated that it normally is a deep station fish often hurt during freezes on Sanibel Island, Florida. Longley and Hildebrand (1941:128) described the species as "a very common nocturnal feeder that schools by day about coral stacks and among gorgonians" and stated that it feeds on worms, crustaceans, lamellibranchs, and gastropods.

The common grunt is abundant at Key West and appears to be generally restricted in its range to the Atlantic and Gulf coasts of the southern United States, although what appears to be stragglers have been reported from North Carolina (Smith, 1907:293) and Chesapeake Bay (Hildebrand and Schroeder, 1928:260).

Bathystoma aurolineatum rimator (Jordan and Swain). Tomtate. Four specimens of this grunt were taken in the trawl during the investigation. The examples ranged in size from 18 to 60 mm and were caught from deep flats and sloping sides of flats. One specimen, 18 mm in length, was taken in June, when the surface temperature was 23.9°C. and the salinity 30.0 ppt. Two individuals captured in July (temperature: 30.0°C.; salinity: 26.7 ppt.) were 22 mm in length. The largest specimen, 60 mm in length, was caught in September, immediately following a hurricane, when the temperature was 27.1°C. and the salinity 17.5 ppt.

This species did not appear to be overly common at Cedar Key, although it has been described as abundant at other localities within its range. Adults were not seen during the investigation. Jordan and Evermann (1898:1309) stated that at Pensacola and Key West the adults are not numerous, but the young swarm about wharves and shores everywhere.

Orthopristis chrysopterus (Linnaeus). Pigfish. A total of 1,791 pigfish was taken in 57 regular collections during the study. Thirty-five additional specimens were caught in exploratory collections. Pigfish were caught throughout the year except in January, although they were considerably more abundant during warm months. Ninety-nine per cent of the fish caught in regular collections were taken from June through November, and during the following May. Only 17 specimens, comprising one per cent of the total catch, were captured from December through April. The average mean monthly temperature during the season when pigfish were abundant was 25.2°C., and the salinity was 25.1 ppt. The average temperature and salinity for the period from December through April were 15.9°C. and 26.5 ppt., respectively. In the early part of the year, specimens ranging in size from 75 to 115 mm comprised most of the catch, and they were taken from channels and deep flats with sparse vegetation. When young fish appeared in abundance in May, they mainly occupied the shallow flats, which, by this time, supported considerable

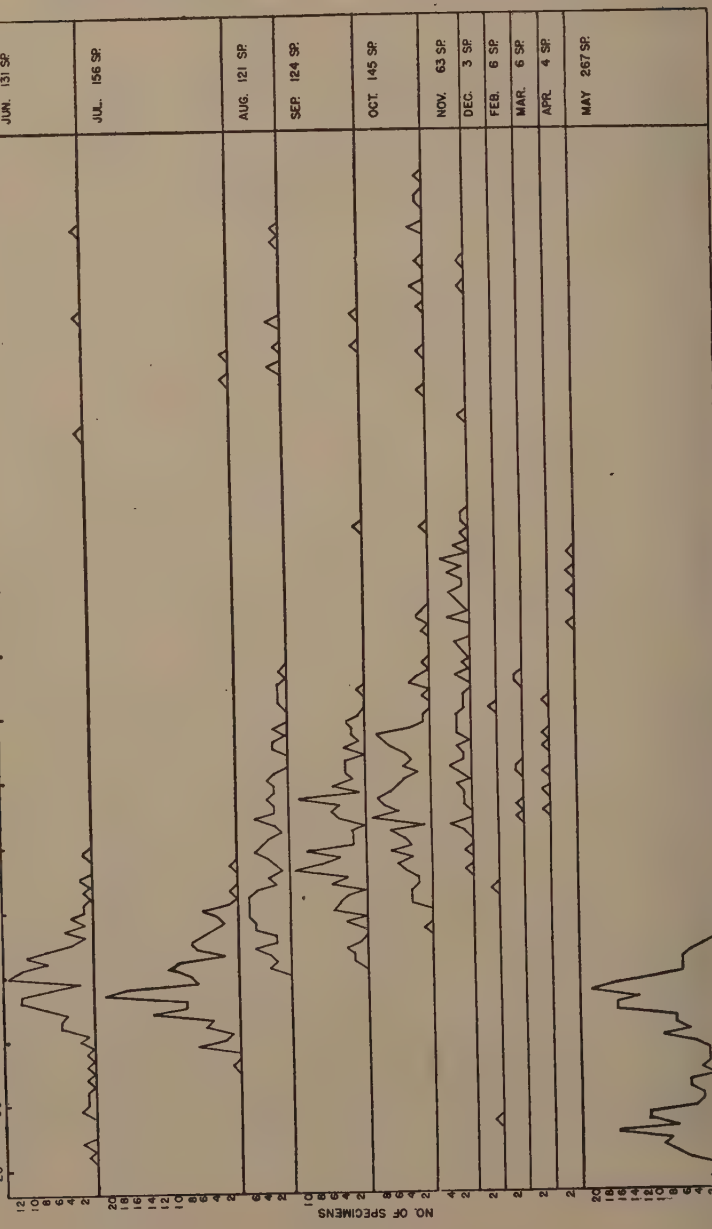


FIGURE 8. Standard Length-Frequency Data of *Orthopristis chrysopterus*.

plant growth. During summer and fall, it appeared that the fish were generally more abundant on deep flats and edges of channels. Gunter (1945:62) found this species to be present on the Texas coast at all seasons of the year and stated that it was most abundant in the Gulf in November, possibly after leaving the bays, and most abundant in bays in the spring. Smith (1907:291) reported that the pigfish is one of the most common food fishes of the North Carolina coast, occurring in all the sounds and salt-water estuaries, and is abundant and present throughout the year at Beaufort.

Spawning apparently takes place in spring, since by the time young fish were first collected they had attained a length of from 23 to 28 mm. The bimodal length frequency curve shown in May (Figure 8) suggests two breeding peaks, or growth spurts, during the season. Adult females captured in July showed signs of developing gonads, although they were far from ripe. Gunter (*loc. cit.*) reported ripe males to be present in March and April on the Texas coast and stated that spawning takes place prior to June. Smith (*loc. cit.*) stated that the spawning season is May and June in North Carolina, and Hildebrand and Schroeder (1928:258) found that spawning takes place in spring in Chesapeake Bay.

Stomach contents of 61 specimens of pigfish revealed a varied diet. Food items found in 55 of the stomachs which contained food are shown (percentage frequency of occurrence) for fish of three size groups in Table 3.

TABLE 3. FOOD OF *Orthopristis chrysopterus*

	% *Frequency of Occurrence*		
Food Item	*25-50 mm 6 Stomachs*	*51-150 mm 39 Stomachs*	*151-170 mm 10 Stomachs*
Copepods	83.3	38.4	—
Ostracods	50.0	—	—
Amphipods	—	53.8	10.0
Shrimps	16.6	56.4	40.0
Crabs	—	5.1	20.0
Mollusks	—	—	20.0
Polychaetes	16.6	7.7	60.0
Fishes	—	5.1	—
Insects	—	—	10.0

In addition to the more conspicuous food organisms listed in Table 3, many stomachs contained varying amounts of plant detritus and sand, indicating a certain amount of bottom grazing by this species. Hildebrand and Schroeder (1928:258) found the food of pigfish in Chesapeake Bay to consist mainly of annelids, with crustaceans, mollusks, insect larvae, fish, and vegetable debris in minor quantities.

SPARIDAE

Calamus arctifrons Goode and Bean. Grass Porgy. This species was taken throughout the period from June through December, with the exception of August. A total of 43 specimens was collected from shallow and deep flats and from channels approximately 16 to 18 feet in depth. Surface temperatures

and salinities during the months of capture ranged from 7.8° to 32.2°C., and from 9.7 to 33.8 ppt., respectively. The average mean temperature was 26.1°C., and the average mean salinity, 25.1 ppt. Specimens taken ranged from 19 to 140 mm in length.

An early spring breeding season for this species was suggested by the small individuals caught in June and July.

Stomachs of sixteen examples were examined. Of these, crustaceans, including copepods, amphipods, mysids, and shrimps, were found in thirteen; remains of pelecypod and gastropod mollusks (*Mitrella* sp. and *Bittium* sp.) in eleven; and polychaetes in one.

Lagodon rhomboides (Linnaeus). Pinfish. A total of 5,132 specimens of pinfish was captured during the course of study. Of the total, 4,480 individuals were taken in 106 regular trawl collections, while 652 were caught in seven exploratory collections. Most of the specimens ranged from 20 to 90 mm in length; only 56 examples larger than 100 mm were taken in the trawl. The species was present throughout the year in the shallow waters about Cedar Key, although the numbers were considerably diminished in December, January, and February. The catch in regular collections during those winter months amounted to only 6.4 per cent of the total catch. The average mean monthly temperature during the period of least abundance was 13.5°C. as compared with an average mean of 23.9°C. for the remaining nine months. The average mean salinity in the winter was 27.0 ppt., and for the rest of the year it was 25.2 ppt. During the warm months the species appeared to be quite ubiquitous in its local distribution; young fish were found in considerable numbers over the flats, and adults occurred abundantly in channels as well as on the flats. Throughout the year, approximately two-thirds of all fish caught were taken from shallow flats; the remainder was collected mostly on deep flats, with a small number having been taken in channels. Few fish were taken over sandy bottom or where vegetation was not present. The flats supported lush vegetation during the warm months when pinfish were most abundant. Gunter (1945:63) similarly found seasonal variations in abundance of this species in Texas localities.

Spawning apparently takes place in fall in the Cedar Key region. Young fish, 10 to 20 mm in length, first appeared in collections in late November, although not in considerable numbers. By late December or early January, specimens ranging in size from 15 to 25 mm were becoming abundant on the flats. Figure 9 shows length-frequencies of the fish and demonstrates two size groups to be present during the first part of the year, while a third group is vaguely indicated in April and May. The breeding season did not appear to be an extended one, since by June no fish less than 25 mm long were caught. No fully ripe adults were captured during the year, although one male, 115 mm in length, caught in September, was examined, and the gonads showed some development. Hildebrand and Schroeder (1928:266) stated that the pinfish apparently does not spawn in Chesapeake Bay, and, according to their evidence, it is a winter spawner. Gunter (*loc. cit.*) failed to take spawning or ripe individuals during his investigation along the Texas coast. He reported that the smallest specimens first came into the catch in January and continued

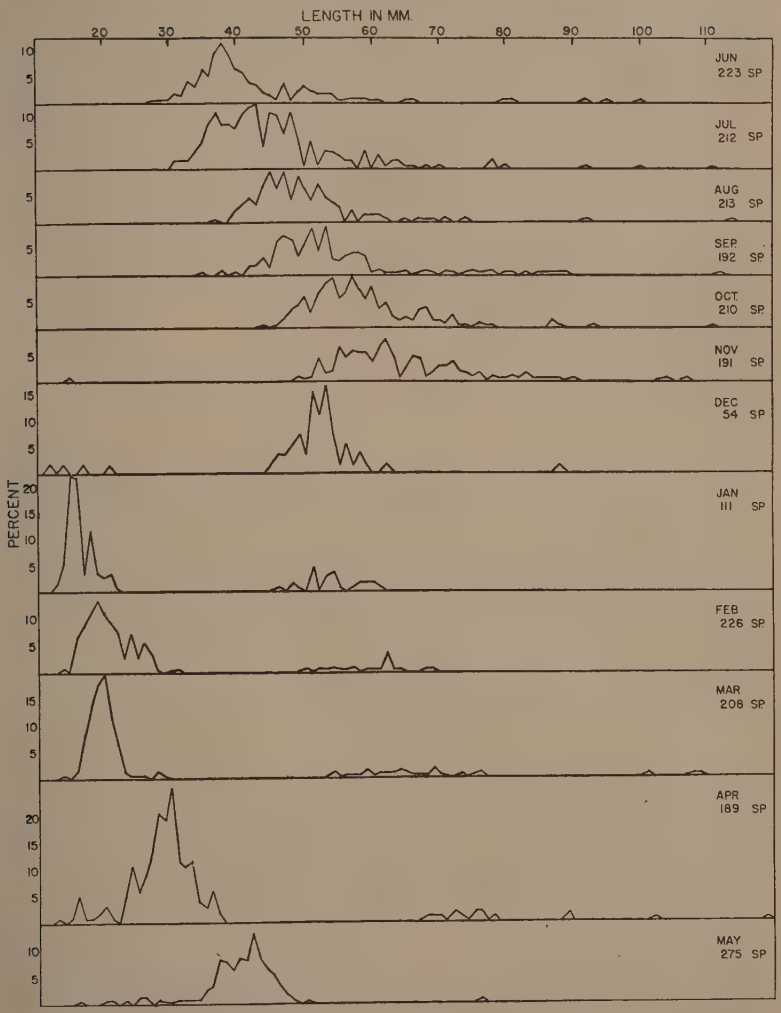


FIGURE 9. Standard Length-Frequency Data of *Lagodon rhomboides*.

to come in until March. Gunter further stated (*loc. cit.*, 64) that the time of appearance of the young indicates that spawning takes place in winter, probably in the open Gulf near the passes.

An examination of the stomach contents of 65 individuals, ranging in size

from 15 to 128 mm, showed that crustaceans such as amphipods, copepods, shrimp, and crabs form the major element in the diet of this species. Pelecypod and gastropod mollusks and plant detritus occurred in some of the stomachs. Shown in Table 4 are the various food items and the percentage frequency of occurrence of those items in stomachs of pinfish of three size groups.

TABLE 4. FOOD OF *Lagodon rhomboides*

	% Frequency of Occurrence		
Food Item	*15-50 mm 17 Stomachs*	*51-100 mm 32 Stomachs*	*101-128 mm 16 Stomachs*
Copepods	29.4	65.6	25.0
Amphipods	52.9	18.7	18.7
Shrimps	58.8	37.7	25.0
Crabs	—	9.4	—
Mollusks	—	12.5	18.7
Fish	—	3.1	—
Plant detritus	—	3.1	—
Organic detritus and mud	—	34.4	—

Smith (1907:300) reported that the food of pinfish at Beaufort, North Carolina, is quite varied, being composed of small fish, worms, crustaceans, mollusks, and seaweed. Hildebrand and Schroeder (*op. cit.*, 265) indicated that vegetable debris is apparently the most important item in the diet of this species in Chesapeake Bay, although crustaceans, mollusks, and annelids also were found. Gunter (*loc. cit.*) found plant material in the form of algae or grass in seven of eight pinfish stomachs examined and suggested that the lack of plant material on the Gulf beach probably accounts for the absence of the pinfish in that environment. The present study indicated that, although plant material was taken in considerable quantity, crustaceans were the main food substances, and that the crustaceans were usually more abundant in the thickly vegetated areas, thus the presence of pinfish in those same regions.

Archosargus probatocephalus (Walbaum). Sheepshead. None of these fish was taken in the collecting gear during the investigation, although adults of over one foot in total length, weighing 2 to 3 pounds, were caught abundantly from the pier on hook-and-line during November, 1950. Jordan and Swain (1884:232) listed it as abundant at Cedar Key in November, 1883.

Smith (1907:301) reported that spawning occurs in the spring and that young fish from 1.5 to 7 inches long are found at Beaufort Harbor, North Carolina, in summer.

Diplodus holbrooki (Bean). Spot-tail Pinfish. Thirty-five specimens of the spot-tail pinfish were taken in the trawl from the deep flats near Atsena Otie Key from September through November, and in May. Twenty individuals taken during the September-November period ranged from 56 to 90 mm in length, with a mean of 69 mm. The surface temperature and salinity during the period ranged from 15.5° to 22.9°C., and 9.7 to 28.6 ppt., respectively. Fifteen specimens taken during May, 1951, when the mean temperature was

24.5°C., and the mean salinity was 25.2 ppt., measured 29 to 39 mm in length, with a mean length of 32.8 mm. All of these smaller specimens were taken from areas of sparse vegetation over a bottom of sandy mud.

The size of the May individuals would indicate a spring breeding similar to that of *Lagodon rhomboides*. In one specimen, 90 mm in length, the gonads were developed, but not mature. Although this species has been reported at Tortugas (Longley and Hildebrand, 1941:133), where it was found uncommonly, and at North Carolina (Smith, 1907:303), where it was said to be common, nothing has been given on its breeding habits heretofore.

Twelve stomachs of fish from the collection were examined. Of nine stomachs from the September-November series, copepods and/or crustacean remains were found in seven, algae in four, and polychaete worms in one; one was empty. The May specimens had eaten mysids, copepods, and bryozoans.

Cedar Key is usually recognized as the northernmost limit of the distribution of this species in the Gulf.

LEIOGNATHIDAE

Eucinostomus gula (Cuvier and Valenciennes). Common Mojarra. Five hundred and seventy-one examples of this mojarra were taken in 47 collections during the period from June through January. The fish, which ranged in size from 14 to 118 mm, were collected from various habitats, although a majority were caught from deep flats and sloping sides of shallow flats in areas of sparse vegetation. The temperature during the months of capture varied from 7.2° to 32.2°C., and the salinity ranged from 9.7 to 33.8 ppt. No fish were caught from February through May.

The smallest fish, 14 to 17 mm in length, were found in July, although individuals ranging in size from 17 to 20 mm occurred in trawl hauls through November. One female mojarra, 81 mm in length, taken in November, had well developed ova in the ovaries. Length-frequency data indicated some growth of the species during its relatively short stay in the shallow waters of the area.

Food of the species, as revealed by examination of 55 stomachs, consisted mostly of copepods and polychaete worms. Of 41 stomachs which contained food, copepods occurred in 65.8 per cent, and polychaetes in 51.2 per cent. Shrimps were found in 9.7 per cent, amphipods in 7.3 per cent, and mysids in 7.3 per cent of the specimens.

Kilby (1950:114) suggested that this species and *E. argenteus*, as well as diverging in the characters described by Longley and Hildebrand (1941:136-139), are ecologically distinct, an opinion supported by data obtained during the present study. As shown previously and in the following section, of 573 mojarras collected during the investigation, only two were *E. argenteus*. Conversely, Kilby (*op. cit.*, 113-117) caught 2,417 *E. argenteus* throughout the marsh at Cedar Key as compared to only 312 specimens of *E. gula*, most of which were taken from beach areas farthest from the marsh.

Gunter (1945:65) found mojarras to be common on the Texas coast in summer, fall, and early winter, and, like the Cedar Key population, absent from shallow waters in late winter and spring. *E. gula* was not reported from

Chesapeake Bay (Hildebrand and Schroeder, 1928), although it was described as abundant at Beaufort Harbor, North Carolina (Smith, 1907:305).

Eucinostomus argenteus Baird and Girard. Silver Mojarra. Only two specimens of this fish were collected in the trawl during the investigation. Both were caught on the same day from similar habitats near islands with marshy shores. The islands were approximately two miles apart. The examples were 66 and 77 mm in length and were taken in November when the surface temperature was 15.5°C., and the salinity 21.2 ppt. Two additional specimens, 44 and 47 mm in length, were caught in a beam trawl during the same month in 1949, from a shallow flat on the north shore of Snake Key. The water temperature was 14.5°C., and mean salinity during the month was 25.2 ppt.

The occurrence of this species in the marsh at Cedar Key and in fresh water at Homosassa Springs, Florida (Herald and Strickland, 1949:106) suggests a tolerance to a wide range in salinity.

Longley and Hildebrand (1941:139) found the young of this species to be common about the flats in the vicinity of the Tortugas and gave the range as "Atlantic coast of tropical America, sometimes straying northward to North Carolina." It appears that the Cedar Key records represent a northward extension of the Gulf distribution of *E. argenteus,* although the lack of information may be due to taxonomic confusion of *E. gula* and *E. argenteus* by previous authors.

Eucinostomus lefroyi (Goode). Mojarra. Jordan and Swain (1884:233) recorded one specimen of this mojarra and stated that the specimen represented the most northern record for the species. None was taken during the present investigation.

Sciaenidae

Bairdiella chrysura (Lacépède). Silver Perch, Yellowtail. A total of 636 examples of *B. chrysura* was caught during the investigation; 495 specimens were taken in 50 regular trawl hauls, while 142 fish were captured in exploratory collections with trawl, seine, and push net. The species was found to be much more abundant during the warm months than in winter. Of the specimens caught in regular collections, approximately 97 per cent were taken from June through November and in May. The average mean surface temperature during that period was 25.2°C., and the salinity 25.1 ppt., as compared with a temperature of 15.9°C. and salinity of 26.5 ppt. for the winter period, when only 12 fish were caught. Collecting data revealed that this species was more abundant on deep flats than in any other habitat studied. Approximately 57 per cent of the specimens caught were taken from deep flats, 33 per cent were taken from shallow flats, and the remainder was caught in channels and island coves. Kilby (1950:122) reported only seven specimens from the marsh area at Cedar Key, this information, together with data from the present study, indicating strongly that *B. chrysura* is primarily an open water inhabitant. Gunter (1945:66) caught specimens at all months of the year in Texas, although the fish was almost entirely absent from Copano Bay from November to March and present in the Gulf only in November and January.

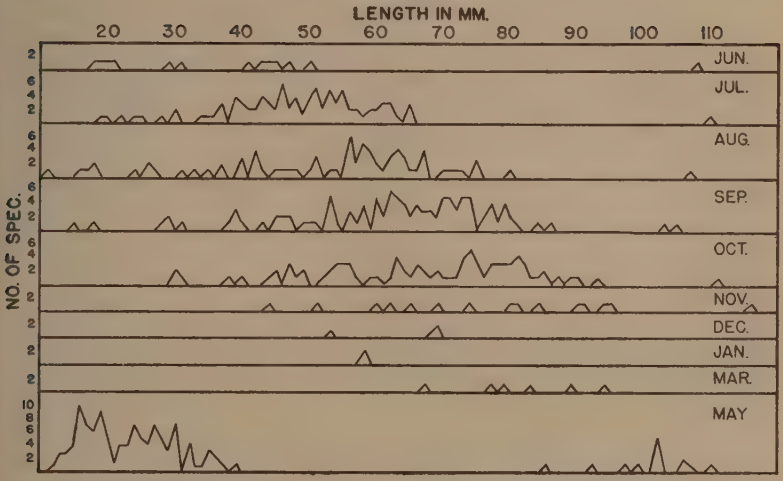


FIGURE 10. Standard Length-Frequency Data of *Bairdiella chrysura.*

Young fish, ranging from 15 to 20 mm in length, were present in June, 1950, when the present investigation was begun, and continued to appear in collections through September. Fish of the 20 to 31 mm size range were taken in the push net as early as May, 1950, however, and Figure 10 shows that young of the year appeared in the trawl collections in May, 1951. One female with ripe ovaries was taken in June. From the preceding data it appears that spawning takes place in the Cedar Key area in spring. Gunter (*loc. cit.*) stated that spawning occurs on the Texas coast in the spring in the brackish waters of the coastal lagoon, and that the smallest fish appeared in June and July in 1941. Hildebrand and Schroeder (1928:280) reported that spawning takes place in late spring and early summer in Chesapeake Bay.

As is shown in Table 5, food of 51 examples of this species, ranging in size from 25 to 130 mm, consisted predominantly of crustacean forms, including various species of shrimps, copepods, and amphipods. Fishes, crabs, mollusks, and polychaete worms were occasionally ingested. This agrees essentially with the findings of Hildebrand and Schroeder (*loc. cit.*) who stated that the diet of Chesapeake Bay yellowtails consists in the main of small and minute crustaceans, with annelids and fishes being foods of less importance.

Leiostomus xanthurus Lacépède. Spot. Three hundred and fifty-five specimens of this species were caught by various types of gear during the investigation. Ten specimens were taken in the trawl in September and from January through May. Three hundred and forty-five examples, ranging from 16 to 57 mm in length, were taken with a seine from the very edge of shallow water along beaches from January through May. The average mean monthly surface temperature for that period was 18.3°C., and the salinity was 26.4 ppt. The

TABLE 5. FOOD OF *Bairdiella chrysura*

	% Frequency of Occurrence	
Food Item	*25-99 mm 45 Stomachs*	*100-130 mm 6 Stomachs*
Shrimps	73.3	33.3
Copepods	40.0	—
Amphipods	33.3	16.6
Crabs	—	16.6
Crustacean debris	4.4	66.6
Mollusks	6.6	—
Fishes	4.4	16.6
Polychaetes	2.2	—

largest specimens were taken in the trawl in September and in March and were 127 and 123 mm in length, respectively. Young examples, in addition to being present in shallow water along sandy beaches, were also found in channels, deep flats, and shallow flats in January and February and were taken in the trawl. Adults were found to be present in the inshore area throughout most of the year, being more numerous in spring and summer than in mid-winter, however.

Spawning apparently takes place in winter and early spring in the Cedar Key area. Seventy-seven young, ranging from 16 to 21 mm in length (modally 18-20 mm), were caught in early January, and 264 specimens, ranging in size from 17 to 25 mm (modally 19-21 mm), in February. By March the young were not abundant, and three specimens caught were 27, 29, and 57 mm in length. Kilby (1950:125) found fish less than 20 mm long present during January, February, March, and May at Cedar Key and stated that a breeding season lasting about the first three months of the year is indicated. He further stated that length-frequency curves indicate that the January young reach sizes between about 70 and 85 mm in June. Gunter (1945:71) found that small fish came into the catch in Texas in April at total length of from 23 to 93 mm. Hildebrand and Schroeder (1928:274) found that along the Atlantic coast spawning takes place in late autumn and probably during the winter, and apparently at sea.

Stomachs of three specimens, 82, 123, and 127 mm in length, contained mysids, copepods, amphipods, and some plant debris. Of seven stomachs from individuals 20 to 57 mm in length, six contained copepods, two contained amphipods, and shrimp and polychaetes were found in one stomach each. Hildebrand and Schroeder (*op. cit.*, 274) found that the food of 157 spots from Chesapeake Bay consisted mainly of small and minute crustaceans and annelids, with lesser amounts of small mollusks, fish, and vegetable debris.

Seasonal migrations of this species appear to be more pronounced at other localities within its range than at Cedar Key. Gunter (*loc. cit.*) demonstrated that spots were found in Copano Bay in spring and summer and suggested that the fish seem to leave the bays in midwinter and go into the Gulf. Hildebrand and Schroeder (*loc. cit.*, 274) stated that a general migration of the species from Chesapeake Bay takes place in September and throughout October.

Menticirrhus americanus (Linnaeus). Whiting. Twelve whiting, 36 to 162 mm in length, were taken from September through December. Three specimens, 36, 49, and 95 mm in length, were caught in regular collections in September, October, and November, respectively, and all were taken from deep flats. The surface temperatures at the times of capture were 27.1,° 25.5°, and 15.5°C., while the salinity readings were 17.5, 25.5, and 21.2 ppt. Eight examples, ranging in size from 40 to 162 mm, were caught in exploratory collections in a deep (16-18 feet) channel, and one specimen, 76 mm in length, was taken from a deep flat during the same day. The surface temperature was 10.0°C. and the salinity 24.8 ppt. Adult whiting were fairly common in the shallow waters from April through December.

Spawning apparently takes place in early spring and summer in the Cedar Key area. Ripe females, approximately 230 mm in length, were found to be present in April and in August. Young fish were not taken until fall, however, and they ranged from 36 to 49 mm in length. Gunter (1945:73) referred to fish with well-developed roe during April, May, and June in Louisiana and stated that the spawning season must be long, since he found individuals with developing roe in March in Aransas Bay, Texas, and another with large roe in the same area in November.

Of five stomachs, from fish 59 to 162 mm in length, which contained food, mysids occurred in four, copepods in three, polychaetes in one, and small mud crabs in one. Hildebrand and Schroeder (1928:293) found the food of 21 specimens of this species from Chesapeake Bay to be 85 per cent crustacean and 15 per cent fish.

Seasonal movements of this species, similar to those observed at Cedar Key, have been reported by various writers. Gunter (*loc. cit.*) demonstrated that the fish was caught less often during winter months than during other seasons and stated that the fish apparently nearly vacated Aransas Bay in January and February, although it was present in previous and following months. Smith (1907:322) reported that *M. americanus* is the most abundant in the Beaufort, North Carolina, area in spring, but is also present in fall, when it schools on the outer beaches; however, it is almost entirely absent from the Beaufort waters in summer.

Pogonias cromis (Linnaeus). Drum. None of this species was taken in the trawl collections during the investigation. Adult individuals, according to commercial fishermen, were most common in deeper waters in the spring. Young drum were taken with hook-and-line from around the pilings of the city pier in September, and were approximately 160 mm in length.

Breeding apparently takes place in spring. Fishermen claimed that adults caught them contain matured roe, and Kilby (1950:128) captured young examples, 17 to 43 mm in length, in May. Pearson (1929) found that the main spawning season of drum on the Texas coast is from February to May.

Sciaenops ocellata (Linnaeus). Redfish, Red Drum. None of this species was captured in the trawl during the investigation. Specimens were taken on hook-and-line in late summer, fall, and winter, and large individuals were observed in commercial catches in late fall, when they seemed to be present in greater numbers than during other seasons. The rather pronounced seasonal

occurrence of redfish at Cedar Key agrees with the findings of Gunter (1945:68), who stated that, on the Texas coast, the greatest numbers of fish were caught in the fall and winter, with few fish taken in the spring and early summer.

No evidence of spawning was found during the study, although field experience suggests a late summer or early fall breeding in the Cedar Key area. Kilby (1950:129) caught small specimens of redfish from open waters, outer marsh pools, and water courses in the marsh during September and October. Gunter (*loc. cit.*) stated that actual observations on spawning redfish have not been reported, although large fish congregate in the fall along the Gulf beaches near passes, where they doubtless spawn.

Observations on the food of redfish indicated that they are voracious feeders, taking both bottom-dwelling and swimming organisms. Gunter (*op. cit.*, 69) found the food of Texas specimens to consist mainly of fish and crustaceans, with algae and grass taken also. Hildebrand and Schroeder (1928:277) reported that the food of this species in Chesapeake Bay consists of crustaceans, the smaller individuals having eaten mostly *Gammarus* and *Mysis*, while the larger fish fed on shrimp.

The redfish is apparently common throughout most of its range from Texas to Chesapeake Bay and sometimse northward, although it was not reported at Tortugas by Longley and Hildebrand (1941). Jordan (1884:148) stated that the fish is scarce at Key West.

Pareques acuminatus umbrosus (Jordan and Evermann). Ribbonfish. One specimen of this species, 33 mm in length, is included in the Cedar Key collection. It was taken during the fall of 1948 from the edge of a hole on the flats north of Seahorse Island.

Longley and Hildebrand (1941:144) stated that at Tortugas this species becomes more active at dusk and is not particularly venturesome during the day. Smith (1907:326) recorded specimens of ribbonfish from Beaufort Harbor, North Carolina, although he was inclined to consider them as stragglers, since the recorded range was from Charleston, through the West Indies, to Brazil.

Cynoscion arenarius Ginsburg. Sand Trout, Sand Weakfish. Fifteen sand trout were taken in the trawl in five collections during the investigation. Seven individuals, 39 to 58 mm in length, were caught from the sloping sides of a shallow flat in September, when the surface temperature was 27.1°C., and the salinity was 17.5 ppt. Four examples, ranging in size from 69 to 78 mm., were captured from deep flats in November; the temperature was 15.5°C. and the salinity 21.2 ppt. In December, two specimens (72 and 75 mm in length) were taken from a deep channel (16-18 feet), and two (80 and 84 mm in length) from a deep flat; the surface temperature was 10.0°C., and the salinity 24.8 ppt. Adults were found in greatest numbers during spring, although this species did not appear to be nearly as common as *C. nebulosus*.

Sexually mature adults were noted in spring, around April. Very young individuals were not captured. The smallest examples were taken in September and ranged from 39 to 58 mm in length, with the mean size of seven specimens

being 51.0 mm. Gunter (1945:76) found young fish from 18 to 38 mm in standard length in April, May, June, and September in Texas, which he felt indicated a long breeding season.

The food of *C. arenarius* was observed to be mostly fishes and larger crustacean forms.

This species has been frequently confused with a closely related form, *Cynoscion nothus* (Holbrook), although Ginsburg (1929:71-85; 1931:144) has shown morphological and habitat differences between the two. All of the Cedar Key specimens examined agreed with the description of *C. arenarius*, particularly in respect to anal ray count (11 in *C. arenarius* as compared with eight or nine in *C. nothus*).

Cynoscion nebulosus (Cuvier and Valenciennes). Spotted Weakfish, Speckled Trout. One hundred and twenty spotted trout, ranging from 18 to 130 mm in length, were taken in the trawl in 40 collections. Over 90 per cent of the fish were caught from shallow and deep flats. Adults of the species were present in the shallow waters about Cedar Key throughout the year, and the young were common from April through January.

The smallest fish, 18 mm in length, was taken in April, when the temperature of the water was 17.5°C., and the salinity was 24.7 ppt. Individuals of the size group 20 to 25 mm were caught in August and October, indicating an extended summer and fall breeding season during 1950.

Moody (1950) studied this species at Cedar Key from October, 1948, to December, 1949, and his findings are summarized (pp. 169-170) as follows:

> The spotted trout was found to be resident throughout the year, and to prefer the shallow grassy inshore areas. Seasonal movements into the rivers and deeper streams along the coast were observed to take place in late winter, primarily in January and February, to escape the occasional low water temperatures which occur in the shallow portions of the area.
>
> Spawning occurred from late March or early April to October. The young appear in the shallow grassy areas prior to June, and are found there until late in winter.
>
> Growth was rapid. A length of approximately 130 mm was attained by the first winter and 250 mm by the second winter after spawning.
>
> The trout become mature by the time they reach 240 to 250 mm in length, or by the second or possibly third winter.
>
> The food of the young and adult was found to consist of various forms of marine fish and crustacea. The young fed on copepods, mysids, carid shrimp, and small marine fish, while the adults fed primarily on large marine fish and peneid shrimp.

This species, like several other marine forms, shows marked euryhaline and eurythermic tendencies. At Cedar Key, spotted trout were collected in a salinity range of 17.5 to 31.5 ppt. and in temperatures which ranged from 11.8° to 28.9°C. Gunter (1945:76-77) caught specimens when the temperature was 8.1° and 34.9°C., and in salinities from 5.0 to 20.0 ppt. Herald and Strickland (1949:107) recorded *C. nebulosus* in the fresh waters of Homosassa Springs, Florida, where the temperature usually ranges between 23° and 25°C.

the year around.

At Cedar Key, this species is second only to the mullet in commercial importance. Thousands of pounds are taken annually by net and hook-and-line fishermen.

Ephippidae

Chaetodipterus faber (Broussonet). Spadefish. Three spadefish were taken during the period of investigation at Cedar Key. One specimen, 20 mm in length, was taken in the trawl from a channel in June, when the surface temperature was 28.9°C., and the salinity was 31.5 ppt.; another individual, 33.5 mm in length, was caught in the push net from a shallow, grassy flat in July (temperature 26.1°C.; salinity: 24.0 ppt.). The third spadefish, 46 mm in length, was caught in the trawl from a deep channel in December, when the surface temperature was 10.0°C., and the salinity 24.8 ppt. Spadefish approximately 110 mm in length were caught from beneath the city pier in August, 1951.

The presence of young of the year, approximately 20 mm in length, in trawl catches and around pilings and floating wrack, would indicate a single spawning during the year, taking place in spring. Similar observations were made at Fort Myers Beach, Florida, during July, 1949. The young, which were colored a rich black, and with a perfectly transparent caudal fin, were found very close to barnacle-covered pilings. When disturbed, the fish darted in among the barnacles; if the escape route was blocked they would remain motionless and could be caught easily with the hand.

Kilby (1950:130) recorded one specimen, 20 mm in length, taken from the inshore shallows of the bay at Cedar Key. Gunter (1945:79) took 23 individuals which ranged from 62 to 195 mm in total length; these were taken on the Texas coast, mostly during the spring and summer months. He stated that this species apparently preferred higher salinities, since he failed to take specimens where the salinity was less than 11.1 ppt. Hildebrand and Schroeder (1928:307) reported specimens ranging in size from 55 to 120 mm and noted that spawning takes place during the summer in Chesapeake Bay. Smith (1907:335) listed the spadefish for Beaufort Harbor, North Carolina, where it reached a length of three feet. He found the fish to inhabit rocky areas, wrecks, and pilings, where it searched for food which consists of "small crustaceans, worms, etc." Spadefish were found in North Carolina only in summer, and ripe male and female fish occurred in early June.

Scorpaenidae

Scorpaena brasiliensis Cuvier and Valenciennes. One specimen of scorpion fish, 49 mm in length, was taken in October from the shallow flats near Atsena Otie Key. The water temperature and salinity at the time of collection were 23.9°C. and 21.0 ppt., respectively.

Gunter (1945:159) reported the presence of this species on the coast of Texas, and Longley and Hildebrand (1941:187) stated that it is common in the deep channels within the atoll at Tortugas, where the maximum size appears to be about 150 mm. Smith (1907:329) obtained specimens of *S. brasiliensis*

in Beaufort Harbor, North Carolina, all of which were under two inches in length.

TRIGLIDAE

Prionotus martis Ginsburg. Sea Robin. Three sea robins which agreed closely with the description of this species given by Ginsburg (1950:502) were taken in the trawl at Cedar Key. All of the specimens were taken from a deep (16-18 feet) channel of rock and shell bottom in December, when the surface temperature was 10.0°C. and the salinity was 24.8 ppt. The fish were 54, 68, and 166 mm in length.

Prionotus scitulus latifrons Ginsburg. Gulf Slender Sea Robin. One hundred and twenty-three examples of this sea robin were taken in the trawl during all months. Fifty-four per cent of the specimens taken in regular collections were caught from deep flats and areas where the flats sloped toward channels, 30.0 per cent from channels, 7.8 per cent from shallow flats, and 7.0 per cent from a sandy mud cove near Seahorse Island. Surface temperatures when fish were collected ranged from 11.8°C. in December to 30.6°C. in July. Salinities varied from 17.5 ppt. in September to 31.5 ppt. in June.

No breeding adults were collected at Cedar Key, although a female (145 mm in length) taken in November showed slight ovarian development, and a male (147 mm in length) caught in December appeared to be near breeding condition. Young fish, 20 to 25 mm in length, were captured in June, August, October, January, and May. Smith (1907:362) stated that *P. carolinus*, a closely related species, spawns in spring at Beaufort, North Carolina.

Stomach content analyses of 13 specimens, ranging in size from 39 to 147 mm, revealed that crustaceans were the most important elements in the diet. Nine of the fish had eaten mysids; copepods were found in five, amphipods in five, and peneid shrimp in three of the stomachs. Polychaetes had been ingested by four of the individuals, including two of the largest specimens. Hildebrand and Schroeder (1928:314) found the food of *P. carolinus* in Chesapeake Bay to consist pricipally of crustaceans, the most important ones being *Mysis*, amphipods, and isopods.

Gunter (1945:80) reported that during the investigation on the Texas coast *P. scitulus* was taken only from December to April, except for three fish taken in August, and that, except for the August specimens, none was caught at a temperature higher than 22.4°C.

Prionotus tribulus crassiceps Ginsburg. Gulf Sea Robin. Fifty-three of these sea robins were caught in the trawl. They were taken in all months except July (1950) and May (1951). Of the specimens taken in regular trawl collections, 86.8 per cent were captured from November through March. These sea robins, like *P. s. latifrons*, were found most commonly in channels and on deep flats, with *P. t. crassiceps* occurring in greatest numbers in channels. Of the total catch of this species, 52.6 per cent were found in trawl hauls made in channels, 31.5 per cent were captured from deep flats, and the remaining 16.0 per cent were from shallow flats and an island cove.

No individuals with ripened gonads were taken, and nothing was learned of the breeding time of this species. Young fish, 25 to 30 mm in length, were

present from August through January.

Five stomachs which contained food were examined, and various crustaceans were found to make up the bulk of the diet of this species. Small crabs had been eaten by two fish; amphipods occurred in two stomachs, shrimp in one, and one stomach contained traces of crustacean remains. The gastropod, *Bittium* sp., was represented in the food of this sea robin by one specimen.

Gunter (1945:80) reported that on the Texas coast *P. tribulus* was caught in the least numbers in the summer and that no fish were caught in the bays during the winter, although taken in the Gulf in January.

Labridae

Lachnolaimus maximus (Walbaum). Hogfish. Five specimens of this species were taken during the course of the present work. They were collected from June through September from a shallow grassy flat near Atsena Otie Key and ranged in size from 44 to 108 mm. Surface temperatures during those months ranged from 22.8° to 32.2°C., and the salinity varied from 9.7 to 33.8 ppt. The lower salinity was recorded on September 12, following a hurricane which struck Cedar Key on September 4-5, 1950.

Food of the hogfish in the Cedar Key vicinity consisted of crustaceans, pelecypods, and the gastropod, *Mitrella*. Longley and Hildebrand (1941:188) stated that it feeds freely by day, and that stomachs examined by them contained broken univalve and bivalve shells, and bits of the test and spines of *Echinometra*.

From the number of specimens captured it would appear that *L. maximus* is not overly common in the region. Longley and Hildebrand (*op. cit.*, 187) found the hogfish to be common and widely distributed over the reefs at Tortugas. The apparent scarcity of the species at Cedar Key suggests that these specimens may be stragglers, since the range of the form is usually described as being from the West Indies north to Key West and Bermuda (Jordan and Evermann, 1898:1580; Jordan, Evermann, and Clark, 1930:425).

Halichoeres bivitattus (Bloch). Slippery Dick. Nine examples of this species were taken in four trawl collections in September and October, 1950, and April, 1951. One specimen, 72 mm in length, was caught from a deep flat in September; the surface temperature was 27.1°C., and the salinity 17.1 ppt. In October (temperature: 24.5°C.; salinity, 25.5 ppt.), five individuals, ranging from 60 to 73 mm in length, were caught from a shallow grassy flat. Two hauls made on the same day in April over shallow flats contained three specimens. The temperature of the water when the collections were made was 18.0°C., and the salinity was 22.4 ppt.

This species has been reported as far north as Beaufort, North Carolina (Smith, 1907:331). It was also recorded for Pensacola (Jordan and Gilbert, 1882:287-288). It is apparently not so abundant toward the northern limits of its range as in South Florida and the West Indies. Longley and Hildebrand (1941:191) stated that this species inhabits grassy bottom and also is common about coral stacks and gorgonians, and on algae-covered bottom.

SCARIDAE

Cryptotomus auropunctatus (Cuvier and Valenciennes). Parrotfish. Four specimens were collected at Cedar Key during the investigation. One specimen, 135 mm in length, was caught from a shallow, grassy flat in September, when the surface temperature was 27.1°C., and the salinity was 17.5 ppt., the lowered salinity having been due to hurricane rains one week prior to the collection. The remaining three individuals were also taken from shallow, grassy flats and were caught in a push net during the latter part of October. These October examples were 30, 45, and 52 mm in length. The surface temperatures at which these parrotfish were captured ranged from 23° to 24°C., and the salinities from 21 to 23 ppt.

These fish are generally considered tropical in distribution, and inhabitants of coral reefs. The Cedar Key record probably represents a northward extention of the known range of the species.

GOBIIDAE

Bathygobius soporator catulus (Girard). Sleeper, Mapo. Two examples of this goby were collected during the investigation. One was found in a clam shell on an exposed flat during a low tide; the specimen, taken in October, was 61 mm in length. Another fish, 60 mm in length, was caught in the trawl from a muddy-bottomed cove on the north side of Seahorse Island in November. The temperature of the water was 15.5°C., and the salinity was 21.2 ppt. Kilby (1950:135) recorded four specimens, ranging from 26 to 37 mm in length, from the shore-line waters at Cedar Key. All were caught in November, December, and February, during the times of high salinity and low temperature.

The specimen 61 mm long was a gravid female with the following finray formula: D. VI, 10; A. I, 8; the scale rows were 38-13. Coloration was a marbled effect, with dull greenish-black on cream, with five dark blotches conspicuous on the dorsal half of the sides, and irregular blotches on the lower sides. All fins were dusky.

Longley and Hildebrand (1941:224) reported this fish from tide pools along the shores of islands in the vicinity of Tortugas and indicated the range of the species as "both coasts of tropical America, on the Atlantic northward to Florida." Previous authors have reported the species for various South Florida localities, and Goode and Bean (1879:127) listed it for Pensacola. Jordan and Evermann (1898-2217) wrote that this fish is universally distributed in tropical seas and common almost everywhere within its range.

Gobionellus boleosoma (Jordan and Gilbert). Darting Goby. None of this species was taken in the trawl during the investigation. Fifty-six specimens, captured from shallow flats by means of the push net, were examined. These individuals, which ranged in size from 29 to 50 mm, were caught from May through October, 1950, except for two, which were taken in March and December. The season of greatest abundance was May through August, when 87.5 per cent of the fish were caught. Mean monthly surface temperatures during the last mentioned period ranged from 26.1° to 28.3°C., and the salinity varied from 25.6 to 30.0 ppt.

No evidence of breeding was determined from the larger specimens. The smallest individuals (29 to 31 mm in length) were taken in May, July, and December, although they could hardly be termed juveniles. Gunter (1945:81) found ripe females in Copano Bay, Texas, in November.

Seasonal abundance of the species at Cedar Key is somewhat at variance with Texas occurrence. It has been shown that this fish was most abundant from May through August, while Gunter (*loc. cit.*) found it to be present in two Texas bays from September to January and in May. Ginsburg (1932:26) stated that *G. bolesoma* is the most common and widespread scaled goby within its range from North Carolina to Panama.

Gobionellus stigmaturus (Goode and Bean). Spot-tailed Goby. Kilby (1950:137) reported two specimens caught in mud-bottomed Gulf shore waters in October and November. None was caught during the present investigation.

Microgobius gulosus (Girard). Large-mouthed Goby. Twenty-six examples, ranging in size from 15 to 57 mm, were caught in regular trawl collections in all months except August, September, October, January, and February, although two specimens were captured in October and two in February in exploratory hauls. The fish was found in all habitats studied, being present even on shallow flats with sparse vegetation during the middle of winter, when low tides left the flats exposed for several hours. With a push net, over 150 specimens were collected from shallow flats in all months during the period from April, 1950, through April, 1951, except November.

Male gobies of this species with nearly ripe testes were observed in June, 1950, and one gravid female was found in May, 1951. Small specimens, 15 to 20 mm in length, were contained in the trawl and push net collections in May, June, and October, 1950, and would indicate a protracted breeding season. Kilby (1950:135-136) caught 256 specimens of this species from vegetated areas at Bayport, Florida, and outer marsh pools at Cedar Key and reported that the smallest individuals (12 mm in length) were present in September and May; his data also indicated either an extended breeding season or very slow growth of the young fish.

Examinations of stomachs of specimens 45 to 57 mm in length revealed copepods, mysids, and amphipods (in that order) as the predominant food items in the diet of the species.

Marked seasonal coloration was noted in the individuals taken from flats throughout the year. Those fish caught from April or May through September or October were decidedly dark in color, with the dark configurations on the side pronounced. Specimens taken from November through March were light colored, and the markings rather indistinct. These variations were probably reflections of the seasonal distribution and abundance of vegetation on the flats. In winter, the flats were predominantly sandy with sparse plant growth, whereas in summer, plants were abundant, and much organic detritus covered the sand. Specimens from deep flats and channels were dark colored throughout the year.

Apparently, little is known about this species. Gunter (1945) did not take

the fish on the Texas coast although Baughman (1950b:253) gave records of the species for the Texas coast; Longley and Hildebrand (1941) did not record it as being present at Tortugas. Most of the locality records pertain to Florida areas and include a record by Jordan and Gilbert (1882:294) for Pensacola.

Gobiosoma bosci Lacépède. Naked Goby. None of this species was taken in the trawl during the present study, and of over 100 specimens of gobies taken with a push net on shallow flats, none appeared to be *G. bosci.* Kilby (1950:137) caught 29 examples of this species in four collections from a marsh pool at Cedar Key. The absence of *G. bosci* from the open water areas and flats where *G. robustum* was found commonly suggests distinct ecological restrictions in the two closely related forms.

Gobiosoma robustum Ginsburg. Robust Goby. Sixty-five examples of this species were captured in 25 regular trawl collections during the investigation. In addition, over 100 specimens were taken from shallow flats in the push net. The fish, ranging in size from 11 to 42 mm, were found to be present throughout the year. Both the push net and trawl collections indicated two peaks in the abundance of the fish; one was in mid-winter and the other in mid-summer. Collecting data revealed that more individuals were caught from vegetated flats than from deeper channel habitats. The lowest temperature at which the fish was caught in the trawl was 10.5°C. (February), while the highest was 30.5°C. (June). The salinity ranged from 17.5 ppt. in September to 31.5 ppt. in June. Kilby (1950: 138) caught five specimens of this species in Gulf shore waters in muddy-bottomed areas in December. He suggested that *G. robustum* lives in the bays and approaches the shore only in the coldest months of the year. Data from the present study definitely substantiate his belief.

The breeding season of this species in the Cedar Key area appeared to be an extended one, lasting from spring to fall. Young fish, 11 to 20 mm in length, were caught in June, September, and December. Ripe females were noted in June, while males with developing gonads were observed in April and August.

Contents of 18 stomachs of specimens of *G. robustum* revealed crustaceans to be the most important item in the diet. Shrimp were found in 55.6 per cent of the stomachs, caprellid and gammarid amphipods in 27.8 per cent, and mollusks in 11.1 per cent; copepods had been eaten by one fish.

Noticeable seasonal coloration was exhibited by specimens taken at different times throughout the year. The winter individuals were uniformly light-colored, whereas the fish taken in summer were much darker than the winter specimens, with the vertical dark bars on the sides more intense.

Ginsburg (1933:30) defined the known range of *G. robustum* as extending from Indian River, Florida, to Corpus Christi, Texas, and stated that the fish is a common species in the Gulf.

Opisthognathidae

Opisthognathus maxillosus Poey. Jawfish. One specimen of this species is in the Cedar Key collection. The individual is 90 mm in length and was

caught in inshore waters in December, 1949.

No data concerning the habits of this fish at Cedar Key are at hand. Longley and Hildebrand (1941:240) reported the species at Tortugas and stated that this fish is most commonly, though even there sparsely, distributed over the reefs, where it lives in burrows which abound about coral stacks just beyond the *Thalassia* zone.

Meristic characters of the Cedar Key specimens agree with those given for *O. maxillosus* by Longley and Hildebrand (*op. cit.*, 240-241), except in the number of gill rakers. The Cedar Key specimen has nine developed rakers above the angle of the first gill arch and 21 rakers on the lower limb of the arch, which compares with 11+19 in the Tortugas examples.

As far as can be ascertained, Cedar Key is the northernmost Gulf locality yet reported for the jawfish, the range usually being described as extending from Cuba and the West Indies northward to the Florida Keys.

Uranoscopidae

Astroscopus y-graecum (Cuvier and Valenciennes). Southern Stargazer. The stargazer is represented by eight specimens taken in six collections from flats and channels from December through March. Water temperature during that time varied between 13.0° and 22.0°C., while the salinity ranged from 26.4 to 32.9 ppt. Lengths of individuals were from 15 to 45 mm.

Gunter (1945:82) took six specimens of *A. y-graecum*, ranging from 39 to 232 mm in total length, during winter and summer in Texas. It is interesting to note that the temperature range (11.1° to 22.4°C.) during which the specimens were taken closely parallels those for the Cedar Key collections, although the Texas salinity range (17.7 to 35.5 ppt.) was somewhat broader than that at Cedar Key.

Many authors have made reference to the ability of the stargazer to emit an electrical shock. The Cedar Key specimens did not give a noticeable shock, due probably to the small size of the individuals.

Blenniidae

Paraclinus sp. Blenny. Ten specimens of this unidentified species of blenny were taken in regular collections, and six were caught in exploratory trawl hauls during the investigation. The fish ranged from 28 to 39 mm in length and were taken only during the coldest season of the year, from September through March. The average mean monthly temperature during those months was 18.0°C., and the salinity was 25.4 ppt. Habitat association did not appear to be particularly marked; ten of the fish were caught from deep flats, while six were taken from shallow flats.

The Cedar Key individuals appear to be closely related to *Paraclinus fasciatus* (Steindachner), which, according to Longley and Hildebrand (1941:262), is known from Key West and southward, although it was not found at Tortugas.

Blennius marmoreus Poey. Blenny. One specimen of this blennoid species was captured during the investigation. The individual was 56 mm in length and was taken from a deep flat in December. The bottom was mostly sand

and shell and was devoid of vegetation at the time of capture. The surface temperature was 10.0°C., and the salinity was 24.8 ppt.

Longley and Hildebrand (1941:266) described the habitat and habits of this species as follows:

> This small bottom-haunting fish is sparsely but widely distributed at Tortugas where suitable cover occurs. Rocky tracts, especially if strewn with dead coral perforated by boring bivalves, are likely to harbor it, and it may be found where a single rock lies in sand, or a single coral head in turtle grass, if there is shelter beneath it. It was also seen among the exposed roots of *Thalassia* about the margins of sandy-bottomed holes, or among coral stacks, where it creeps by preference over their dead and caverned surfaces. Usually it finds its shelter ready made; but it may excavate and carry out sand with its mouth, or it may drive the sand out by lying close under a stone, vibrating its body rapidly.

This species is apparently uncommon in the shallow coastal waters north of the Florida Keys. Jordan and Gilbert (1882:301) reported three specimens taken from the stomach of a red snapper at Pensacola.

Hypsoblennius hentzi (LeSueur). Blenny. Ten examples of this species, from 40 to 80 mm long, were taken in the trawl (September through December). The specimens were caught on deep flats and in channels where vegetation was not very abundant and where the bottom was composed of sandy mud with some rock and shell. During the season when the fish were captured, the surface temperatures ranged from 27.1°C. in September to 10.0°C. in December. The salinity range was from 17.5 ppt. in September to 24.8 ppt. in December. Average mean monthly temperature and salinity for the period were 19.7°C. and 23.6 ppt., respectively.

This species is apparently more common on the Atlantic coast than on the Gulf coast, and the assignment of the Cedar Key specimens to *H. hentzi* is made with taxonomic reservations. Baughman (1950b:254) cited references to the species on the Texas coast. Smith (1907:377) stated that the species is abundant on sandy shores and among seaweeds, from North Carolina to Florida. Hildebrand and Schroeder (1928:335) found it infrequently in net catches in the shallow water of Chesapeake Bay, and stated that it may not be as rare as indicated, for it may live where it is inaccessible to nets.

Chasmodes saburrae Jordan and Gilbert. Florida Blenny. One hundred and eighty-four specimens of the Florida blenny were taken in 45 collections throughout the year. They were caught on shallow flats, on deep flats, in channels, and occasionally in clam and conch shells left on the flats by the receding tide. Observations and collecting data indicated that most of the fish were found in areas with muddy bottom and some vegetation. One specimen was found still alive in a shell of *Busycon* six hours after the shell had been taken from the water and into the laboratory.

Figure 11 shows that the youngest specimens were taken during June and July, and that at the same time there was a noticeable absence of adult fish from the collections. A decided difference in sex ratio was noted in February,

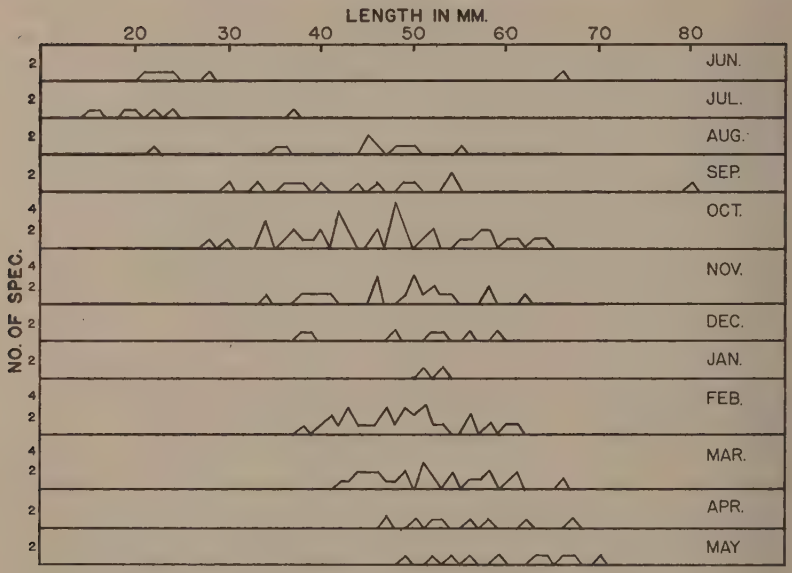


FIGURE 11. Standard Length-Frequency Data of *Chasmodes saburrae*.

when adult males with gonads in various stages of maturity were taken, few adult females being captured during the same period and those showing only slight signs of gonadal development. By April, adult females with mature ovaries were common in the trawl catches, and in May, all specimens showed conspicuous breeding characteristics. In one female, 52 mm in length, the belly was much distended by ovaries approximately 12x3.5 mm in size and containing hundreds of pinkish eggs, one millimeter in diameter. The first and second anal spines, which in males were normally short and fleshy, became enlarged and bulbous during the spawning season. As in many other fishes, the males of *C. saburrae* are more intensely pigmented during the breeding season. The male of this species is generally larger than the female; in a series of 33 individuals taken at various times during the year, 21 males averaged 56.7 mm, and 12 females averaged 49.1 mm in length.

Thirty stomachs from individuals taken at various seasons were examined. Gammarid amphipods were found in 28 of the total stomachs and were present in all seasons. Four of the stomachs held small mud crabs; pelecypods and gastopods (*Bittium* sp.) were found in four stomachs. Shrimps had been eaten by four fish captured in November and February. One example, taken in June, had eaten numerous embryos of an undetermined species of fish. One stomach was empty.

One specimen, the identification of which has been debated, constitutes the

only Texas record of this fish (Baughman, 1950b:254). *C. saburrae* occurs at Pensacola, the type locality (Jordan and Gilbert, 1882:298). It was not recorded for Tortugas (Longley and Hildebrand, 1941), Key West (Jordan, 1884), or for the Atlantic coast. The range is apparently restricted to the Gulf coast.

Ophidiidae

Ophidion holbrooki (Putnam). Cusk Eel. This species is represented in the Cedar Key collection by eleven specimens, taken in August, October, January, and February. Six of the specimens were taken in regular trawl collections, while five were obtained from bait-shrimpers' trawls. All of the specimens were collected on the deeper flats. A specimen taken in August was 118 mm in length and was caught when the surface temperature was 29.5°C. and the salinity 27.8 ppt. Four individuals, 141 to 193 mm in length, were taken in October at a temperature of 24.0°C. and a salinity of 21.8 ppt. The January specimens were taken in two collections. One haul in early January (temperature: 11.1°C.; salinity: 27.2 ppt.) contained one cusk eel 114 mm in length; the second January collection (temperature: 15.0°C.; salinity: 28.2 ppt.) contained four fish, which ranged in size from 138 to 210 mm. One example, 121 mm in length, was caught in February when the surface temperature was 21.0°C. and the salinity 28.9 ppt.

Otophidium welshi Nichols and Breder. Striped Cusk Eel. A single specimen of this species was taken in December from the main ship channel south of Seahorse Island. The individual was 215 mm in length and was collected in the trawl at a depth of approximately 16 feet. The temperature of the water was 10.0°C., and the salinity was 24.8 ppt.

Gunter (1945:82) recorded two of these cusk eels of approximately the same size as the Cedar Key specimen in March, when the temperature was near 17.0°C., and the salinity 35.0 ppt.

Jordan, Evermann, and Clark (1930:486) defined the range of *O. welshi* as the coast of Texas. The collection of this species at Cedar Key apparently constitutes an extension of the known range.

Batrachoididae

Opsanus beta Goode and Bean. Toadfish. One hundred and sixty-three toadfish were collected during the study, with all months represented. Of the total specimens, 126 were caught in regular trawl collections, 26 were taken in exploratory hauls, and 11 were taken on a shallow flat with the seine and by digging into burrows. The greatest abundance of the species, as reflected in routine trawl hauls, was found to occur from June through September, when 80.2 per cent of the specimens were taken. Most of the fish were caught from channels and deep flats where the bottom was composed of muddy sand with rock and shell. The temperature range during these months was from 32.2° to 22.8°C., with the average of the mean monthly readings being 27.9°C. Salinities varied from 33.8 to 9.7 ppt., with the average mean monthly at 25.5 ppt. In February, 1951, nine specimens, 42 to 76 mm in length, were caught by hand from burrows of varying depths and shapes on

a shallow flat exposed at low tide. The surface temperature of the water as it was ebbing was 14.5°C., and the salinity was 28.8 ppt. Burrows were found only on that part of the flat which was exposed. Only one fish was found in each burrow, although, in some instances, snapping shrimp, *Crangon* sp., were also found in the burrows. It was not determined if the toadfish dug the burrows or merely inhabited those of some other animal. This burrowing trait suggests an explanation for the scarcity of specimens during the colder months, from November through April. During these months the flats were mostly devoid of vegetation which ordinarily would provide cover for the fish. With the vegetation sparse, the fish perhaps sought concealment in the burrows and were not caught in the trawl. Smith (1907:373), Gunter (1945:83), and Kilby (1950:131) have each made reference to the preference of this species for a habitat in and around oyster bars and areas of shell and rock bottom.

There was no evidence for a clearly defined breeding season at Cedar Key. A sexually mature female was taken in September, and nearly ripe males were found in June and March. The presence of small fish, 20 to 25 mm in length, from June through September would seem to indicate an extended breeding time. Hildebrand and Schroeder (1928:338) found females with large eggs from April to the latter part of October and stated that spawning apparently takes place throughout the summer.

Examinations of 26 stomachs of *O. beta* showed that, of 22 which contained food, crustaceans were the predominant items. Crabs of various species occurred in 81.8 per cent of the stomachs, and peneid and crangonid shrimps were found in 31.8 per cent, for the greatest frequency of occurrence. Hermit crabs, mollusks, and amphipods were taken as food by five of the fish, and fishes were eaten by two of the toadfish; one *Lagodon rhomboides* 54 mm in length had been ingested by a toadfish 140 mm in length. These food items of the toadfish at Cedar Key were essentially the same as those reported by Smith (1907:374) for the species on the North Carolina coast; namely, fish, blue crabs, spider crabs, stone crabs, fiddler crabs, hermit crabs, shrimp, various bivalve and univalve mollusks, and sea urchins.

HETEROSOMATA

Bothidae

Etropus crossotus atlanticus (Parr). Atlantic Fringed Flounder. This species was collected in the trawl during all months except March and May. Of the sixty specimens caught in regular collections, 60.0 per cent were taken from channels. The remainder of the fish was captured from deep flats or edges of channels at seasons when the vegetation was sparse, and mud or organic detritus the predominant feature of the bottom. These specimens, which ranged in size from 23 to 108 mm in length, were collected at temperatures varying from 16.7° to 30.6°C., and salinities from 17.5 to 30.0 ppt.

Small individuals of 23 to 25 mm in length were caught in June and October, respectively, suggesting an extended breeding season during spring and summer. No sexually mature adults were observed.

Polychaete worms formed the most important single item, from the stand-

point of frequency of occurrence, in the diet of these flounders, having been found in 11 out of 12 stomachs from specimens 69 to 108 mm in length. Copepods occurred in six stomachs, shrimps in three, and amphipods and unidentifiable crustacean debris in two. Copepods were usually taken in large quantities, there being hundreds of these crustaceans in some of the stomachs.

Gunter (1945:86) found *E. crossotus* to be scarce in January, February, and March, and most abundant from October to January on the Texas coast. The data on Cedar Key specimens indicate that this species was present at all seasons.

Paralichthys albigutta Jordan and Gilbert. Gulf Flounder. Two hundred and one examples of this species were taken in regular trawl collections during all months except December. Three specimens were taken in exploratory hauls

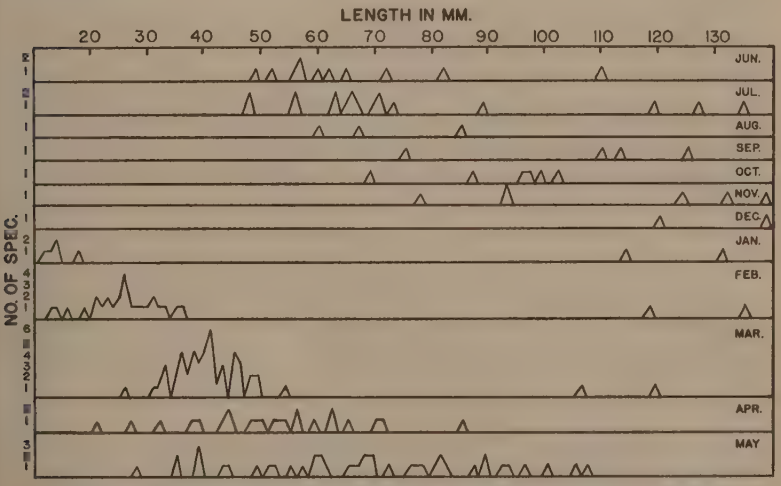


FIGURE 12. Standard Length-Frequency Data of *Paralichthys albigutta*.

in a deep channel in December, however. Nearly all of the fish larger than 70 mm in length were caught during warm weather, from sparsely vegetated channels or coves with muddy sand bottom, whereas in winter they were found on shallow flats devoid of thick plant growth. From January through May, young fish were abundant on the shallow flats. The lowest surface temperature at which specimens were taken was 8.3°C. (February), and the highest temperature was 30.6°C. (July). The salinities at which the fish were caught ranged from 17.5 ppt. in September to 31.5 ppt. in June.

The breeding season for this species in the Cedar Key area is apparently late fall or early winter. Gravid females were noted in October, and young fish, 10 to 15 mm in length, were first caught in January. Figure 12 shows

monthly size distribution and indicates rather rapid growth, at least up to 50 mm in length.

Examination of 27 stomachs, from specimens ranging in size from 44 mm to 400 mm in length, revealed that the young fish fed primarily on amphipods and other small crustaceans, and that at the length of approximately 45 mm they began to feed upon fish, which became the main element in the diet as the flounders became larger.

Of the fishes eaten by *P. albigutta*, *Orthopristis chrysopterus* was taken in the greatest numbers, especially in May and June when young *O. chrysopterus* were abundant. *Lagodon rhomboides, Synodus foetens, Anchoa mitchilli diaphana,* an undetermined labrid species, and some unidentified fishes occurred also in stomachs. Smith (1907:389) stated that on the coast of North Carolina *P. albigutta* feeds on fish, shrimps and other small crustaceans, mollusks, and worms.

This species apparently varies in abundance in different localities within its range. Smith (*loc. cit.*) reported that it is common at Beaufort, North Carolina, while Longley and Hildebrand (1941) did not record the species at Tortugas. Gunter (1945:86-87) captured only 12 specimens from Texas bays and the Gulf during his study, although he caught 241 specimens of *P. lethostigma.* Jordan and Swain (1884:233) stated that *P. albigutta* is the most common flounder in the Cedar Key area, and the results of the present study are in agreement.

Achiridae

Trinectes maculatus fasciatus (Lacépède). Southern Hogchoker. Eight hogchokers, ranging from 47 to 120 mm in length, were collected in the trawl. Although present at all seasons, the occurrence of this species in collections was irregular. All of the examples were caught from deep flats or channels, or from shallow flats when vegetation was sparse and the bottom muddy. The temperature range for all collections was 11.8° to 22.8°C., and the salinity varied from 17.5 to 31.5 ppt.

The only evidence of breeding was noted in one female fish, 120 mm in length, taken in January; the gonads appeared to be nearly ripe. Hildebrand and Schroeder (1928: 176) stated that spawning in Chesapeake Bay apparently takes place during late spring and summer.

All of the stomachs examined were found to be empty of food organisms, but usually contained considerable quantities of sand. Hildebrand and Schroeder (*loc. cit.*) noted that the food of 47 specimens was chiefly annelids, but included also a few small crustaceans.

The euryhaline character of this species is demonstrated by its occurrence in sea water of high salt content, brackish waters of the coastal marshes, and inland flat-woods streams (Otter Creek, near Cedar Key) and calcareous springs such as Silver Springs in Marion County, Florida.

While most of the Cedar Key specimens exhibited an immaculate blind side, one specimen was taken in September in which pigmentation was almost complete on the blind side. Jordan and Evermann (1898:2700) discussed the taxonomic importance of this character difference in Gulf and Atlantic forms.

Smith (1907:396-397) reported that the hogchoker is apparently rare at Beaufort, North Carolina, but common in the lower courses of North Carolina rivers. It was not recorded for Tortugas (Longley and Hildebrand, 1941); however, Gunter (1945:87-88) found it to be fairly common on the Texas coast.

Achirus lineatus (Linnaeus). Lined Sole. Thirty-three lined soles were collected from varied habitats. The species was taken in all months except August, January, February, and March. The specimens, which ranged in size from 22 to 46 mm, came from stations in which the temperature varied from 11.8° to 30.0°C. and the salinity ranged from 17.5 to 31.5 ppt.

Small individuals, 22 to 29 mm in length, were caught in October and December. Kilby (1950:140) assumed that a slow growth rate (approximately 22 mm per year) is characteristic for the young of this species, with the breeding season restricted to late summer or early fall. Data from the present study are in agreement insofar as the growth rate is concerned, although a later breeding season during 1950-1951 was indicated.

Food of this species in the Cedar Key area was found to consist mainly of crustacean forms such as copepods and amphipods, and of polychaetes.

Gunter (1945:88) indicated that larger individuals on the Texas coast preferred waters of higher salinities. Data from the Cedar Key investigation show some correlations between size of fish and salinity and may explain the scarcity of large fish on the basis of their having migrated to waters of higher salinity.

Cynoglossidae

Symphurus plagiusa (Linnaeus). Tonguefish. Eighty-seven tonguefish, ranging in size from 31 to 140 mm, were taken in the trawl. There are records for every month of the year. Although found in varied habitats, a majority of the fish were collected from channels and deep flats with muddy bottom and rather sparse vegetation. On the basis of catch data, this species appeared to be most abundant from December through May, when 71.3 per cent of the specimens were caught. The temperature range during those months was 12.2° to 24.5°C., and the salinity was 25.9 to 28.1 ppt. Gunter (1945:88) stated that the tonguefish in Texas definitely prefers waters of high salinity, since over 90 per cent of the specimens were taken where the salinity was over 30 ppt. However, specimens were taken at Cedar Key in September, seven days after a hurricane, when the salinity was 15.4 ppt.

Food of this species at Cedar Key consisted mainly of crustaceans. Copepods and amphipods were most regularly eaten, and ostracods occurred in some of the stomachs. Polychaetes and pelecypods were taken occasionally.

The tonguefish is apparently very common throughout its range. It occurs normally from Texas to Beaufort, North Carolina, although it occurred uncommonly in Chesapeake Bay (Hildebrand and Schroeder, 1928:178).

DISCOCEPHALI

Echeneidae

Echeneis naucrates Linnaeus. Sharksucker. One sharksucker was captured with the trawl in August in a shallow channel. The specimen was 222 mm

in length. The surface temperature was 28.0°C., and the salinity was 29.0 ppt.

This species is more common in the area than collecting data indicate. Considerable numbers of the fish are taken sporadically on hook-and-line from the city pier at Cedar Key.

PLECTOGNATHI

Monacanthidae

Monacanthus ciliatus (Mitchill). Filefish. More than 90 specimens of this fish were collected from July through March. They ranged in size from 13 to 60 mm, with the smallest individuals being captured in July and August. Sixty-six examples were taken in the trawl from August through March. Most of the trawl-caught fish were collected on shallow flats until January, when they were taken from deeper areas and channels. The remainder of the filefish was taken in a push net on shallow flats, during low tides from July through October. The extremely low water in late fall and winter, which exposed the flats and killed the vegetation, probably made the areas uninhabitable for the species. A collection made on shallow flats in June, 1949, contained seven individuals, 43 to 54 mm in length. From the data, it appears that *M. ciliatus* is present throughout most of the year in the region.

Food of individuals ranging from 39 to 55 mm in length was composed primarily of copepods and mollusks. Shell debris from pelecypods and gastropod mollusks was contained in most of the stomachs. Amphipods and ostracods had been eaten by some of the fish.

Coloration in these fish is variable, although a mottled phase of dirty gray and dull green seems to be most characteristic. Longley and Hildebrand (1941:295) discussed adaptive coloration exhibited by the Tortugas filefish. The best single character for distinguishing this species from *M. hispidus* appears to be the presence of scales modified as spines on the caudal peduncle of *M. ciliatus*. Longley and Hildebrand (*loc. cit.*) noted the structures and indicated that the enlarged scales seem to be present even in the smallest specimens. Although no measurements were taken, the ventral flap in *M. ciliatus* seems to be larger than in *M. hispidus*, giving an impression of a more angular body outline. This is, however, not as exaggerated, at least in young indivdiuals, as in the line drawing in Breder (1929:226).

As far as was ascertained, the range of this species appears to be restricted to the west coast of Florida, from Pensacola through the Florida Keys.

Monacanthus hispidus (Linnaeus). Filefish. Ninety-four examples of this species, ranging in size from 15 to 82 mm, were taken in the trawl from deep flats, shallow flats, and channels. Specimens were collected during all months from May through December. Approximately 30 individuals, varying from 15 to 48 mm in length, captured on shallow flats with a push net, were examined. These fish were caught from May through November, their absence in December perhaps indicating an exodus from the shallow areas when the winter low tides exposed the flats.

The smallest fish (15 mm in length) occurred in May and October, although

little concerning breeding habits can be inferred. No individuals with developed gonads were observed.

Food of this species proved to be similar to that of *M. ciliatus*. Various amphipods of the group Caprellidea and Gammaridea were consumed most frequently. Pelecypod mollusks and polychaete worms were found in a few stomachs. In Chesapeake Bay, specimens were found to have fed largely on annelids (Hildebrand and Schroeder, 1928:343). At Beaufort, North Carolina, Linton (1905:401) found the food to be bryozoans, small crustaceans and mollusks, gastropod eggs, annelids, small sea urchins, and algae.

Variation in color pattern did not appear to be as marked in this species as in *M. ciliatus*. Most of the examples of *M. hispidus*, particularly those taken during warm months, were uniformly glassy green except for the ventral flap, which in some was a light yellowish color. Longley and Hildebrand (1941:296) described various color patterns among Tortugas filefish of this species. Scalation over the body was uniform, without the spinous areas on the caudal peduncle exhibited by *M. ciliatus*. Due to the smaller flap, the outline of this species appeared more rounded than that of *M. ciliatus*.

The range of *M. hispidus* is described by earlier authors as extending from Massachusetts to Brazil. Longley and Hildebrand (*loc. cit.*) defined the range of the fish as the Florida Keys, sometimes straying northward and ranging southward. Baughman (1950b:255) stated that the species is not common on the Texas coast.

Ceratacanthus schoepfi (Walbaum). Foolfish, Filefish. This species was taken from the flats and channels during the months from June to November, except for August. Eight specimens, 50 to 78 mm in length, were collected and, of these, six were taken in channels or on the deeper parts of the flats. Two specimens were seined from shallows along a sandy beach. The temperature range during the times in which foolfish were taken was 15.5° to 32.2°C. The salinity varied from 15.4 to 33.8 ppt.

There was no indication of breeding activity.

Stomachs of two of the specimens contained undetermined vegetation, bryozoans, and copepods. Smith (1907:343) found the foolfish eating succulent algae, bryozoans, shrimp, amphipods, and sea lettuce.

Nearly all authors have noted the variability in coloration exhibited by this species. Hildebrand and Schroeder (1928:344) found coloration to range from dusky blotches and brownish spots, to brownish sides spotted with yellow and orange. Smith (1907:347) described three distinct color phases: a dull greenish-gray, a rich orange-yellow, and a milky-white. At Tortugas, a specimen was streaked with white and olive, with olive sides becoming dusky (Longley and Hildebrand, 1941:292). The Cedar Key individuals were generally a mottled, dull green, passing into dark gray or brown.

Ostraciidae

Lactophrys tricornis (Linnaeus). Cowfish. Examples of this species, ranging from 13 to 165 mm in length, were taken throughout the period from June through December. Eight individuals were caught in the trawl and one in the push net during that time. The surface temperature varied from 28.9° to

10.0°C., and the salinity from 33.8 to 15.4 ppt. (the latter salinity following the September 4-5, 1950, hurricane). Specimens were collected from shallow flats, deep flats, and channels in open water. Kilby (1950) did not find cowfish in the sandy shallows or marsh areas of Cedar Key. This species suffered high mortality during the hurricane.

Examinations of stomachs of *L. tricornis* indicated a diet of undetermined vegetation, algae, and pelecypods.

Longley and Hildebrand (1941:299) found that Tortugas individuals 27 mm long had frontal and lateral spines. The same was true of Cedar Key specimens of the same size, although in the specimens 13 and 23 mm in length there was no indication of either of the pairs of spines. The spines in smaller specimens appeared to be proportionately longer than in adults. Exact proportions were impossible to determine because the spines of the specimens examined had been broken. It appeared also that the spines of young individuals made a 45° angle with the body, while those on adults were pointed forward, almost horizontally.

Noticeable color changes accompanied increase in size in *L. tricornis*. A series of seven specimens collected in March, 1950, at Pass-A-Grille, Florida, by R. Kirk Strawn, showed the following variations in pattern:

27.0 mm, 1 specimen. Venter with 29 blue spots approximately pupillary size, evenly distributed.

35.0 mm, 1 specimen. Spots in the central area of venter rather faint.

35.5 mm, 1 specimen. Only peripheral spots present on venter. Center and most of venter white.

48.0 mm, 1 specimen. Two lateral spots on chin larger than pupil, and one spot at the base of each lateral spine. Remainder of venter immaculate.

50.0 mm, 1 specimen. Chin spots and spots at base of lateral spines indistinct. Remainder of venter immaculate.

51.0 mm, 1 specimen. Chin spots faintly discernible. Spots at base of lateral spine missing. Remainder of venter immaculate.

120.0 mm, 1 specimen. Entire venter immaculate.

It appeared that young cowfish, which were distinctly marked in life with bright blue spots on white ground color on the venter and on gray background on the upper surfaces of the carapace, lost the ventral spotting on reaching lengths between 35 and 50 mm. In addition, the spotting on the carapace became transformed in adults into irregular bandings of light blue on a yellowish to olive background.

Gunter (1945:84) collected two specimens of this species from the Texas coast during 1941-1942. Baughman (1950b:256) found the fish common in shrimp trawls during the summer months. Eleven specimens, 27 to 168 mm in length, were mentioned from Tortugas by Longley and Hildebrand (*loc. cit.*). The species apparently does not range far northward, since Hildebrand and Schroeder (1928) did not report it for Chesapeake Bay, nor did Smith (1907) record *L. tricornis* for the North Carolina coast, although a footnote in the last mentioned work (p. 344) states that *L. tricornis* is known from Charleston to Chesapeake Bay.

TETRAODONTIDAE

Sphoeroides spengleri (Bloch). Southern Puffer. This species is apparently uncommon in the shallow waters about Cedar Key. Only two specimens were taken in the trawl during 1950-1951. One individual, 29 mm in length, was caught from a deep flat near Atsena Otie Key in June, when the surface temperature was 23.9°C. and the salinity 30.0 ppt. In September, when the temperature was 27.1°C. and the salinity 17.5 ppt., an individual, 53 mm in length, was captured from the upper slope of a channel-edge near Seahorse Island. Another puffer, 37 mm in length, was caught in a push net on a shallow flat near Atsena Otie Key in September (temperature: 26.7°C.; salinity: 20.0 ppt.).

S. spengleri appears to be uncommon throughout most of its range along the Gulf coast of the United States except at Tortugas (Longley and Hildebrand, 1941:299-300), where it is commonly caught in the deeper channels and on grass flats. Baughman (1950b:256) stated that this puffer is not especially common on the Texas coast.

The Cedar Key specimens agreed closely with the description of the Tortugas individuals given by Longley and Hildebrand (*loc. cit.*). Examination of examples revealed the upper surfaces to be smooth; the longitudinal series of black spots and the two vertical dark bars on the caudal fin were well-defined.

Sphoeroides nephelus (Goode and Bean). Puffer, Swellfish. This species was taken during every month of the period of the study. Trawl collections at Cedar Key contained 102 specimens ranging in size from 14 to 189 mm and taken at various temperatures between 11.8° and 30.6°C., and at salinities varying from 17.5 to 31.5 ppt. The fish was found in all areas which were investigated and did not appear to be more abundant in one habitat than in another.

Two nearly ripe male fish were captured during the year; one, 189 mm in length, was taken in October, and another, 155 mm in length, was caught in March. Young puffers, approximately 15 mm in length, were found in June and October, 1950, and the following May. Breeding of this species in the Cedar Key area apparently takes place during spring and summer. Hildebrand and Schroeder (1928:348) stated that *S. maculatus* breeds in May in Chesapeake Bay.

The diet of six specimens of *S. nephelus* consisted of crabs and mollusks. Of six stomachs which contained food, crabs, which appeared to be small *Callinectes sapidus*, were contained in five, and mollusks, mostly pelecypods, occurred in three. These data agree with those of Hildebrand and Schroeder (*loc. cit.*), who found that *S. maculatus* in Chesapeake Bay fed principally on small crustaceans such as crabs, shrimp, isopods, and amphipods, and a few small mollusks, annelids, and traces of algae.

DIODONTIDAE

Chilomycterus schoepfi (Walbaum). Spiny Boxfish. A total of 73 spiny boxfish was taken during the investigation. Of these specimens, 44 were cap-

tured in the trawl in regular collections, 11 were caught in the trawl during exploratory hauls, and 18 individuals were collected in the push net. All of the fish taken in regular collections were caught from June through November, 1940, and in May, 1951, except for one specimen caught in March, 1951. Four individuals were taken in a deep (16-18 feet) channel in an exploratory haul in December. The mean monthly temperatures from June through November ranged from 28.3° to 17.2°C., with the average at 25.4°C. The mean salinities during that same period varied from 30.0 to 19.9 ppt. In December, the mean temperature was 12.2°C., and the salinity was 25.9 ppt. During the period from January through April, or the season of low catch (one specimen), mean temperatures ranged from 13.3° to 20.0°C., with an average of 16.8°C., while the salinities varied from 27.4 to 23.3 ppt. (average mean: 26.7 ppt.). In May, 1951, when four boxfish were caught, the mean temperature was 24.5°C., and salinity 25.2 ppt. During summer and fall, when the fish were common, 54.5 per cent of the catch was made on deep flats, 18.2 per cent came in channels, and the remainder was evenly divided between shallow flats and an island cove. Small individuals (12 to 90 mm in length) were common on shallow flats from June through September and were taken with a push net.

Hildebrand and Schroeder (1928:351) recorded the species only in May and October in Chesapeake Bay and stated that nothing definite is known about the spawning or the rate of growth of this fish. At Cedar Key, male boxfish with testes in advanced stage of development were taken in September, while a nearly ripe female, 175 mm in length, was caught in March. Young fish, 10 to 20 mm in length, were present from June through August, 1950, and again in May, 1951. No specimens less than 45 mm in length were captured during October and November. These data suggest an early spring spawning of comparatively short duration and rather rapid growth during fall and early winter.

Food of the spiny boxfish at Cedar Key consisted predominantly of mollusks. Of ten stomachs examined, seven contained crushed shells of pelecypods and gastropods. Two stomachs, each of which contained over one hundred gastropods, *Bittium* sp. and *Mitrella* sp., were noted in November. One fish had eaten an echinoid, *Mellita* sp., and another had eaten one unidentified mud crab. Hildebrand and Schroeder (*loc. cit.*) found the food of six specimens from Chesapeake Bay to be hermit crabs which had been taken in the shells which they occupied, and the shells crushed.

As was found at Cedar Key, this species is apparently more abundant in shallow waters during summer throughout most of its range. Baughman (1950b:257) stated that the very young were quite common in Rockport Harbor, Texas, during June and July. Jordan and Gilbert (1882:306), who listed it as *Chilomycterus geometricus,* stated that it was common at Galveston in March. Longley and Hildebrand (1941:302) found that *C. schoepfi* was erratic in appearance about Tortugas; young were observed during August, 1924, in various areas, although the species had not been observed during the preceding ten years. Gunter (1945:84) collected the species only in Aransas Bay, Texas, and stated that the species evidently prefers waters of high salinities

and probably was not found in the Gulf because of the absence of reef animals on which it feeds, such as oysters and barnacles, in the areas where the trawl hauls were made. The reference to habitat agrees with the Cedar Key data discussed previously, wherein most of the specimens were found in channels and deep flats with muddy rock and shell bottom.

PEDICULATI

Antennaridae

Histrio gibba (Mitchill). Sargassum Fish. A single specimen of this fish, approximately 110 mm in length, is in the personal collection of Mr. St. Clair Whitman of Cedar Key. The fish was captured in 1949 near the edge of a channel.

This example agrees with the description by Garman (1896) in finray formula (D. III, 12; A. 7; V. 5). The first dorsal spine is not produced, being less than one-half as long as the second. The terminal "bait" of the first spine is bulbous with hair-like projections. The illustration of a Tortugas specimen given by Longley and Hildebrand (1941:Pl. 34) agrees in general with the Cedar Key specimen, particularly in the distribution of creamy coloration about the eye.

The known range of *H. gibba* is usually cited as the West Indies north to Key West and Tortugas (Jordan, Evermann, and Clark, 1930:505). Various localities for the Texas coast (Baughman, 1950b:257), in addition to the present Cedar Key record, considerably extend the known range.

Ogcocephalidae

Ogcocephalus nasutus (Cuvier and Valenciennes). Short-nosed Batfish. Forty-one batfish, provisionally identified as *O. nasutus,* were caught in regular trawl collections. All months except December and May were represented. Six specimens, one in October, three in December, and two in January, were taken in exploratory collections during the investigation. All of the fish ranged from 110 to 173 mm in length, except for two specimens, which were 78 and 96 mm long. Slightly over 50 per cent of the fish were caught in June, July, and August, although other data did not suggest marked seasonal migrations. A distinct association with a particular habitat in the Cedar Key area was indicated by the collecting data and field observations. Eighty per cent of the specimens were captured in rocky or shell-bottom channels and from flats of sparse vegetation. The remaining individuals were taken on deep flats, shallow flats, and in a mud-bottomed island cove. Of these, only two were taken from a typical shallow flat, and they were caught in November and February, when the flat was devoid of plant life.

Evidence of spawning by this species in the Cedar Key area was not well defined. Four fish with distended gonads were observed in July, October, January, and April. The smallest fish were taken in February and July and were 78 to 87 mm in length, respectively.

Twenty stomachs, three of which were empty, were examined for food. Large quantities of mollusks were found in 15 of the stomachs, and polychaetes had been eaten by two of the fish. Those specimens which had ingested

mollusks usually contained hundreds of a wide variety of small pelecypods and gastropods. In one stomach, which contained over a hundred mollusks, Dr. M. J. Westfall, of the Department of Biology, University of Florida, identified the following gastropods: *Nassarius vivex, Cerithium muscarium, Urosalpinx tampaensis, Bittium* sp., *Mitrella* sp., *Modulus modulus, Olivella mutica, Haminoea elegans,* and *Anachis avara.*

Roundworms, provisionally identified by Dr. Ralph V. Bangham, Wooster College, as *Contracaecum* sp., were found by hundreds in the stomachs and intestines of ten of 20 specimens examined.

The identification of the Cedar Key batfish as *O. nasutus* is based on the characters given by Longley and Hildebrand (1941:311-312). In all of the Cedar Key specimens, except the two smallest individuals, the rostral process is considerably shorter than the diameter of the eye. Of 17 specimens examined, eight have five dorsal rays, while nine have four. Other meristic differences were noted and will be treated in a later report.

Jordan and Swain (1884:234) combined this batfish and *O. cubifrons* under the name *Malthe vespertilio* and described it as very common on sandy bottom in the harbor at Cedar Key. Longley and Hildebrand (*loc. cit.*) separated *Ogocephalus nasutus* and *O. cubifrons* from *O. vespertilio* on the basis of 13 pectoral rays of the former species and the 10 or 11 rays of the latter. The Cedar Key specimens modally have 13 pectoral rays, while five of 23 individuals examined have 12 rays.

The Fish Population of the Cedar Key Area

Components and Local Distribution. The inshore fish population of the waters about Cedar Key is varied, from the standpoint of the number of species present, and generally abundant, in terms of species mass when the number of individuals of each of the various kinds is considered. During the present investigation 122 species of cartilaginous and bony fishes were recorded for the area. These species represent 100 genera and 58 families. It is not implied that these figures represent accurate totals for the local fish fauna, and the limitations imposed by the methods and equipment used during the study must be considered. Some species, such as the cutlass fish, *Trichiurus* sp.; the jewfish, *Promicrops itaira* (Lichtenstein) and *Garrupa nigrita* (Holbrook); and the snook, *Centropomus undecimalis* (Bloch), doubtless occur in the shallow waters occasionally, but concrete evidence or reliable sight records were lacking.

Of 51 families of bony fishes reported for the area, eight are represented in the population by more than three species each. Although the total number of species making up a given fauna may be of some zoogeographic interest as an expression of the highways and barriers operating, it is of far more ecological significance to know the relative population densities of the more abundant forms constituting the fauna. The genera represented by many species and the species represented by many individuals are potent biotic factors in the environment, while the forms represented by the occasional or sporadic straggler obviously contribute little to the community. Shown in Table 6 are the eight families which have the greatest species density, and the number of specimens

of each family taken in 106 representative trawl collections is given. There appears to be little correlation between the number of species of a fish family and the quantitative contribution of the family to the total population.

Table 7 shows the proportions of 63 species in 9,756 specimens taken in 106 representative trawl collections. Although it appears that the eight families listed in Table 6 contributed approximately 65 per cent of the total catch, Table 7 indicates that a single sparid species, *Lagodon rhomboides,* constituted 45.9 per cent of all specimens caught. Obviously, the collection distribution does not accurately represent the make-up of the natural population at any given time. The proportions of *L. rhomboides* and *Orthopristis chrysopterus* (Table 7) are distorted by the great seasonal abundance of young. The positions of the anchovy and mullets are not accurately defined, for, although common on the flats, they eluded capture by the trawl and are therefore not included in the catch data. Thus, to give anything like a true picture of the fauna, every effort had to be made to appraise areal and seasonal fluctuations in the various populations.

TABLE 6. FAMILIES REPRESENTED AT CEDAR KEY BY MORE THAN THREE SPECIES EACH AND THE CONTRIBUTION OF EACH FAMILY TO TRAWL COLLECTIONS

Family	*Number of Species Reported for Cedar Key*	*Number of Specimens Caught in Regular Collections*
Sciaenidae	8	490
Serranidae	7	197
Carangidae	7	2
Syngnathidae	6	889
Gobiidae	6	85
Cyprinodontidae	5	7
Sparidae	4	4,531
Blennidae	4	172
	Total	6,373

Spatial relationships among the fishes of the areas studied involved considerable differential habitat distributions, even within the limited area of a single station. In the shallow waters along the beaches, *Mollienesia latipinna, Membras m. vagrans, Menidia beryllina, Eucinostomus gula,* and various cyprinodonts, and seasonally the young of *Leiostomus xanthurus, Mugil* spp., and *Chaetodipterus faber* were the characteristic inhabitants. *Anchoa mitchilli diaphana, Strongylura* spp., and *Hyporhamphus unifasciatus,* locally widespread, frequently occurred in the beach areas. On the vegetated shallow flats, *Lagodon rhomboides, Syngnathus* spp., *Bairdiella chrysura, Calamus arctifrons, Cynoscion nebulosus, Monacanthus* spp., and *Orthopristis chrysopterus* were found commonly during the warm months and were generally replaced in the winter by such fishes as *Prionotus* spp., *Sphoeroides* spp., *Urophycis floridanus,* and flatfishes. Channels were inhabited by *Ogcocephalus nasutus, Cynoscion arenarius, Hippocampus hudsonius punctulatus,* and flatfishes. Obviously, many of the fishes moved from

TABLE 7. DISTRIBUTION OF SPECIMENS IN 106 MONTHLY TRAWL COLLECTIONS

The following data are given for each form: number of specimens collected, the total number caught during the year, the frequency of each species expressed as per cent of total catch. At the head of each column the number of collections is given. Figures at the botton of the table show the total number of specimens taken monthly, the proportions of each as per cent of total catch, and the average number of specimens per collection. The grand total is given at the lower right.

Month	*Jun.*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Total No. Specimens*	*% Total Catch*
Number of Collections	*8*	*12*	*7*	*9*	*9*	*8*	*6*	*8*	*9*	*12*	*7*	*11*		
Lagodon rhomboides	320	601	366	670	600	555	7	10	39	486	246	580	4,480	45.92
Orthopristis chrysopterus	129	248	95	124	119	63	1	—	6	6	4	966	1,761	18.05
Syngnathus scovelli	20	19	10	28	46	35	45	36	90	138	46	63	576	5.90
Bairdiella chrysura	9	84	39	105	100	15	4	2	—	6	—	114	478	4.89
Eucinostomus gula	2	48	114	45	94	106	1	1	—	—	—	—	411	4.21
Syngnathus floridae	10	18	14	21	61	23	15	7	22	18	12	10	231	2.37
Paralichthys albigutta	14	21	6	4	6	6	—	3	21	50	18	40	189	1.94
Centropristes melanus	12	19	9	37	57	22	—	—	5	4	—	4	169	1.73
Chasmodes saburrae	6	8	9	16	15	19	7	2	25	27	10	9	153	1.56
Opsanus beta	10	17	7	57	23	7	2	1	1	6	2	3	136	1.39
Urophycis floridanus	—	—	—	—	—	—	—	42	54	13	3	—	112	1.15
Prionotus s. latifrons	15	9	2	2	8	16	4	6	8	7	3	9	89	.91
Sphoeroides nephelus	12	4	1	3	6	5	2	4	4	11	5	31	88	.90
Cynoscion nebulosus	2	9	8	11	24	21	5	2	—	1	1	2	86	.88
Monacanthus hispidus	27	3	3	2	4	37	—	—	—	—	—	6	82	.84
Symphurus plagiusa	6	3	1	3	2	4	9	4	5	13	2	16	68	.70
Gobiosoma robustum	24	11	2	4	—	—	1	5	7	1	1	3	59	.60
Micrognathus crinigerus	—	1	—	39	—	1	—	3	1	2	—	1	48	.49
Ogcocephalus nasutus	17	5	11	2	2	2	—	2	1	2	3	—	47	.48
Chilomycterus schoepfi	4	4	3	12	8	6	—	—	—	1	—	4	42	.43
Monacanthus ciliatus	—	—	2	12	12	7	2	3	2	2	—	—	42	.43
Synodus foetens	1	5	8	5	3	5	—	3	4	1	2	2	39	.40
Prionotus t. crassiceps	1	—	1	1	1	5	14	5	1	8	1	—	38	.39
Etropus c. atlanticus	4	2	2	9	3	7	2	1	3	—	3	—	36	.37
Calamus arctifrons	1	4	—	9	14	2	—	—	—	—	—	—	30	.31
Achirus lineatus	6	4	—	2	7	2	1	—	—	—	1	4	27	.28
Microgobius gulosus	6	3	—	—	—	1	1	—	—	2	3	9	25	.26
Hippocampus regulus	—	4	3	—	—	—	1	2	7	2	—	3	22	.23
Diplodus holbrooki	—	—	—	5	—	1	—	—	—	—	—	15	21	.21

Diplectrum formosus	3	1	—	10	4	2	—	—	—	—	—	—	20	.20
Lutianus synagris	—	—	3	7	4	4	—	—	—	—	—	—	18	.18
Paraclinus fasciatus	—	—	—	1	1	3	2	2	2	1	—	—	12	.12
Cynoscion arenarius	—	—	—	7	—	4	—	—	—	—	—	—	11	.11
Leiostomus xanthurus	—	—	—	1	—	—	—	3	3	1	—	1	9	.09
Halichoeres bivittatus	—	—	—	1	—	5	—	—	—	—	3	—	9	.09
Hypsoblennius hentzi	—	—	—	5	1	1	—	—	—	—	—	—	7	.07
Hippocampus h. punctulatus	—	—	—	—	—	—	—	1	3	2	—	—	6	.06
Astroscopus y-graecum	—	—	—	—	—	—	—	1	4	1	—	—	6	.06
Mycteroperca microlepis	1	2	3	—	—	—	—	—	—	—	—	—	6	.06
Syngnathus louisianae	1	2	1	—	1	—	—	—	—	—	—	1	6	.06
Lutianus griseus	—	—	1	3	—	2	—	—	—	—	—	—	6	.06
Ceratacanthus schoepfi	2	1	—	1	—	1	—	—	—	—	—	—	5	.05
Trinectes m. fasciatus	—	—	—	2	—	—	1	—	—	1	—	1	5	.05
Galeichthys felis	—	—	1	—	—	3	—	—	—	—	—	—	4	.04
Bathystoma a. rimator	1	2	—	1	—	—	—	—	—	—	—	—	4	.04
Haemulon plumieri	—	—	—	2	1	1	—	—	—	—	—	—	4	.04
Harengula pensacolae	—	—	—	—	—	4	—	—	—	—	—	—	4	.04
Lactophrys tricornis	—	—	—	2	1	—	—	—	—	—	—	—	3	.03
Lucania parva	—	—	—	—	3	—	—	—	—	—	—	—	3	.03
Menticirrhus americanus	—	—	—	1	1	1	—	—	—	—	—	—	3	.03
Floridichthys c. carpio	—	1	—	—	—	—	1	—	1	—	—	—	3	.03
Anchoa m. diaphana	—	—	—	—	1	—	1	—	—	—	—	—	2	.02
Eucinostomus argenteus	—	—	—	—	—	2	—	—	—	—	—	—	2	.02
Sphoeroides spengleri	1	—	—	1	—	—	—	—	—	—	—	—	2	.02
Lachnolaimus maximus	—	1	—	1	—	—	—	—	—	—	—	—	2	.02
Serraniculus pumilio	—	1	—	—	1	—	—	—	—	—	—	—	2	.02
Echeneis naucrates	—	—	1	—	—	—	—	—	—	—	—	—	1	.01
Ophidion holbrooki	—	—	—	—	—	—	—	—	1	—	—	—	1	.01
Cryptotomus auropunctatus	—	—	—	1	—	—	—	—	—	—	—	—	1	.01
Selene vomer	—	—	—	1	—	—	—	—	—	—	—	—	1	.01
Fundulus g. grandis	—	—	—	—	1	—	—	—	—	—	—	—	1	.01
Bathygobius s. catulus	—	—	—	—	—	1	—	—	—	—	—	—	1	.01
Chaetodipterus faber	1	—	—	—	—	—	—	—	—	—	—	—	1	.01
Total No. of Specimens	668	1,165	726	1,276	1,240	1,002	129	151	320	813	369	1,897	9,756	
Per Cent of Total Catch	6.85	11.94	7.44	13.08	12.71	10.27	1.32	1.55	3.28	8.33	3.78	19.44		
Average Number Specimens per Collection	83.5	97.1	103.7	141.8	137.8	125.2	21.5	18.9	35.5	67.8	52.7	172.4		

one locality to another, particularly during tidal changes and seasonally.

In addition to differences in horizontal distribution, a vertical stratification existed. For example, the near-surface layer was inhabited by such fishes as silversides, halfbeaks, and needlefishes, and characteristically the bottom inhabitants were such forms as flatfishes, blennies, and gobies. Most of the fishes in the population, although closely associated with bottom vegetation, occurred in the stratum between the surface and the bottom.

Some temporal relationships among the fishes were determined by examination of collections made in a particular locality at various seasons. In this manner the elements of the population, their proportions, and the species density at various times of the year were observed. An indication of population change in relation to time is shown by seven similar trawl collections made on a shallow flat at Grassy Key in October (1950), January, February, March, April, early May, and late May (1951) (shown in Table 8). The numbers of individuals of each species captured are shown as percentages of the total catch. Seasonal fluctuations in population composition are strikingly illustrated by a comparison of the catches for October and January, in which, although 21 species are represented, only two were taken in both months.

Environmental Factors

Salinity. The salinity range (based on monthly means) during 1950-1951 was approximately 10 ppt., ranging from 30.0 to 19.9 ppt. The mean monthly salinity for the year was 25.7 ppt. Occasionally the salinity had marked fluctuations, but a return to a more normal level was rapid and no pronounced effects on the fish population were observed. The lowest salinity at which collections were made occurred in September, 1950, when the waters of the shallow areas were diluted 15.4 ppt. At this time nine trawl collections were made at eight different stations, and these contained 1,278 specimens representing 42 species. These nine collections provided one of the most diversified groups of fishes taken during the entire period of investigation. Comparison of fishes taken at this low salinity with Gunter's results (1945) showed that two species, *Selene vomer* and *Lactophrys tricornis,* present in the Cedar Key collection were never taken below a salinity of 30.0 ppt. in Texas. Two other species, *Ogcocephalus nasutus* and *Prionotus scitulus latifrons,* not taken in Texas at salinities lower than 25.0 ppt. and another, *Chilomycterus schoepfi,* not caught at salinities less than 20.0 ppt. were collected at lower salinities at Cedar Key. Other differences in salinity-species correlations were probably not significant.

The only extended season of low salinity during 1950-1951 was from September through November (1950), when the monthly mean range was from 19.9 to 25.9 ppt. (Fig. 2). Eight species were caught only during those months, while three additional species were captured only from August through December. Insufficient evidence is at hand to support a conclusion that the presence of these species was due solely to low salinity, however; this period was also one of cooler water, with a rather steady decline in surface temperature (Fig. 5). Another period of lowered salinity occurred during April and May, 1951, at which time the surface temperature was comparable to that of the fall. None of the eight species caught during the fall was taken during the April-May period.

Since conspicuous correlation of changes in the total fish population with abrupt salinity fluctuations was not observed, and since the general population integrity was maintained during seasons of prolonged low salinity, it appears that salinity is not a critical factor in the environment of the local fauna. Indeed, most of the species of the area are generally conceded to be euryhaline,

TABLE 8. SEASONAL VARIATION IN THE FISH POPULATION AT GRASSY KEY STATION

	Percentage of Collection						
	Oct.	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*Early May*	*Late May*
Lagodon rhomboides	32.8	—	16.1	45.4	56.0	15.1	8.4
Orthopristis chrysopterus	20.0	—	—	—	—	3.0	82.0
Centropristes melanus	20.0	—	—	—	—	—	—
Bairdiella chrysura	2.8	—	—	—	—	—	1.1
Calamus arctifrons	8.5	—	—	—	—	—	—
Diplectrum formosus	2.1	—	—	—	—	—	—
Halichoeres bivittatus	3.6	—	—	—	—	—	—
Eucinostomus gula	1.4	—	—	—	—	—	—
Chilomycterus schoepfi	1.4	—	—	—	—	—	.5
Opsanus beta	.7	—	—	—	—	6.0	—
Syngnathus floridae	2.1	5.9	—	—	—	—	—
Monacanthus hispidus	.7	—	—	—	—	—	.5
Monacanthus ciliatus	3.6	5.9	—	—	—	—	—
Ogcocephalus nasutus	—	5.9	3.2	11.4	—	—	—
Sphoeroides nephelus	—	11.8	12.9	—	8.0	12.0	2.2
Prionotus s. latifrons	—	23.5	—	—	—	—	1.1
Prionotus t. crassiceps	—	11.8	—	4.5	—	—	—
Cynoscion nebulosus	—	5.9	—	—	—	—	.3
Urophycis floridanus	—	11.8	—	—	—	—	—
Etropus c. atlanticus	—	5.9	—	—	—	—	—
Synodus foetens	—	11.8	9.7	—	—	—	.3
Astroscopus y-graecum	—	—	9.7	2.3	—	—	—
Paralichthys albigutta	—	—	41.9	6.8	20.0	21.2	2.2
Syngnathus scovelli	—	—	6.4	25.0	4.0	15.1	1.1
Gobiosoma robustum	—	—	—	2.3	—	—	—
Chasmodes saburrae	—	—	—	2.3	4.0	—	—
Symphurus plagiusa	—	—	—	—	4.0	24.2	—
Microgobius gulosus	—	—	—	—	4.0	—	—
Trinectes m. fasciatus	—	—	—	—	—	3.0	.3
Total Fish per Collection	140	17	31	44	25	33	367
Per cent of Total	21.3	2.6	4.7	6.7	3.8	5.0	55.85

some even to the point of inhabiting fresh water. Herald and Strickland (1949: 99-109) listed for the fresh water of Homossassa Springs, Florida, eight species which occurred commonly in the shallow areas at Cedar Key. The invasion of such springs in Florida by marine species is not uncommon, and the ability of

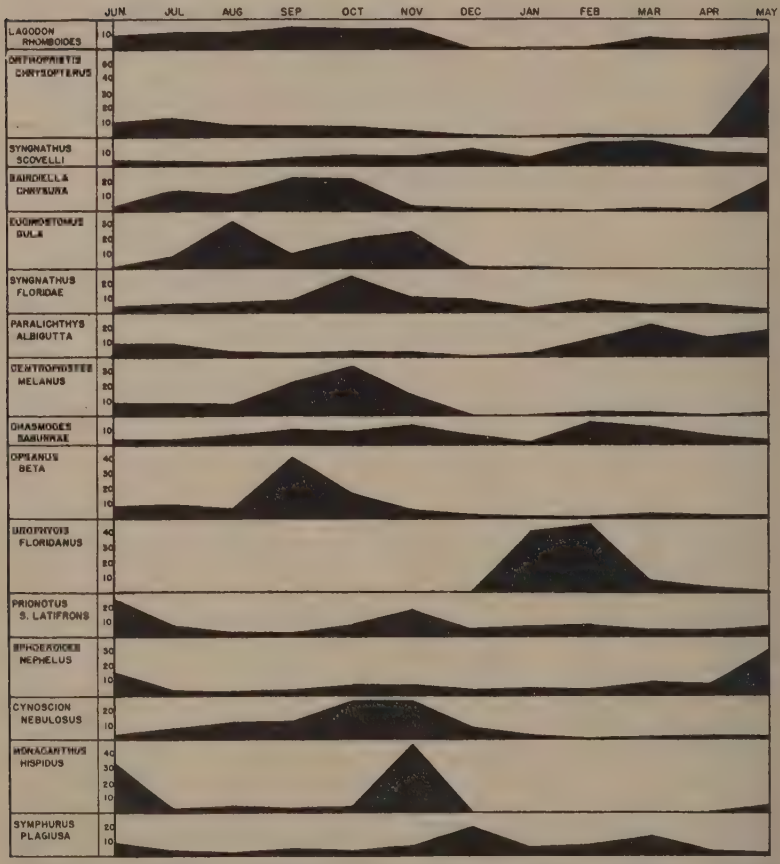


FIGURE 13. Seasonal Variations in Abundance of Sixteen Species in Trawl Collections. Shown in the figure are average numbers of specimens of each species per month (Table 7) presented as per cent of the total of the monthly averages of that species.

the fishes to maintain themselves may be due, in part at least, to the calcareous nature of the water. Breder (1933:57) stated, "Field and laboratory studies have indicated that Ca has a protective value to marine teleosts against the effects of the lower tonicity of fresh water." Smith (1943) has discussed some of the physiological mechanisms and adjustments involved in order for fishes to transgress the salinity barrier.

Since completion of the present manuscript, interesting data on salinity rela-

tionships of marine fishes in this region have been presented by H. T. Odum (1953).

Temperature. The shallow inshore waters are subjected to great and, at times, sudden changes in temperature. The temperature range during 1950-1951 was 16.7° C., and, as a result of cold snaps during the winter, the temperature of the water sometimes varied as much as 10° C. in 48 hours. Under such conditions, seasonal changes in the structure of the fish population might be expected. Such changes were apparent, and it appeared that temperature was one of the more critical factors in the environment. Although it is possible that the population fluctuations were indirect responses to temperature changes, with the fish following food organisms which may have reacted negatively to low temperatures, the presence of considerable numbers of small shrimps and crabs during the winter might indicate that the effect of temperature on the fishes was a direct one.

Of 63 species taken in representative trawl collections (Table 7), 57 were absent entirely or were present only in reduced numbers during the coldest months (December, January). Some species (Figure 13, Table 7) such as *Syngnathus scovelli, Syngnathus floridae, Prionotus scitulus latifrons, Sphoeroides nephelus,* and *Symphurus plagiusa* appeared to be eurythermic to varying extents and were present throughout the year. Other species such as *Lagodon rhomboides, Orthopristis chrysopterus, Bairdiella chrysura, Eucinostomus gula, Cynoscion nebulosus,* and *Monacanthus hispidus* were absent during the cold months. Only one species migrated from deeper waters into the shallow areas during the cold season; Figure 13 shows that *Urophycis floridanus* was captured in the trawl in considerable numbers from January through April, although field observations revealed that it arrived in December. *Symphurus plagiusa* appeared to be more abundant during winter and early spring than at other times of the year.

During the winter months (December, January, and February) the shallow waters were mostly desolate. The bottom vegetation died and during low winter tides the bottom was exposed as scattered broad areas littered with browned vegetation, or else swept clean and exposing bare sand. The invertebrate fauna, generally, was noticeably meager, both in numbers and kinds, except for the aforementioned crabs and shrimps. The dominant fish species in the channels and on flats consisted mostly of *Urophycis floridanus, Syngnathus scovelli, Symphurus plagiusa, Chasmodes saburrae, Prionotus tribulus crassiceps, Syngnathus floridae, Gobiosoma robustum,* and *Prionotus scitulus latifrons.* Along the beaches, *Mollienesia latipinna,* young of *Mugil cephalus* and *Leiostomus xanthurus,* and some cyprinodonts were the main inhabitants. Occasional abrupt cold snaps took a toll of fishes, although this was usually lighter than the mass mortality described by Storey (1937) for Sanibel Island, Florida, and by Gunter (1941a, 1945) for the Texas coast. On one such occassion at Cedar Key, a few dead *Eucinostomus* spp. and *Chilomycterus schoepfi* were observed floating at the surface. Spawning by several species was noted during the winter months. In addition to young *Leiostomus xanthurus* and *Mugil cephalus,* young *Lagodon rhomboides* and *Paralichthys albigutta* first appeared in late winter. The late winter months were also the time of abundant growths of algae on the deep flats and sides of channels. This season produced the smallest collections. Table

7 shows that the average number of fish per trawl haul ranged from 21 to 35.

From March to May breeding was more evident. The winter-spawned young fish were on the flats in great numbers. During this season, the algae was replaced by spermatophytes as the dominant vegetation, and the bottoms of the shallow flats were covered by water at all times. The young of *L. rhomboides* and *P. albigutta* were the most abundant, although these were joined later in the season by large numbers of immature *Orthopristis chrysopterus*. As spring progressed, *Centropristes melanus, Opsanus beta, Chasmodes saburrae,* and *Sphoeroides nephelus* returned in larger numbers, and the mojarras and silversides also became more apparent. Along the shores the populations of cyprinodonts and of *Mollienesia latipinna* increased in size, while the young of *M. cephalus* and *L. xanthurus* apparently migrated to deeper waters. The increase in abundance of fishes during the spring months is indicated in Table 7 in which average numbers of individuals per haul are shown to range from 52 to 172.

Summer witnessed the maximum increase in population density and number of species in the shallow areas. During June, July, and August, the inshore areas became increasingly populated with sharks, rays, needlefishes, silversides, flatfishes, serranids, and numerous others (Table 7). On the flats the bottom supported abundant vegetation and held much organic detritus which harbored large numbers of food organisms. Echinoids, holothurians, crabs, and shrimps became common. Energetic feeding by many organisms was in evidence throughout the area. Egrets, herons, and gulls were fishing, and during calm periods the striking of large fishes and the sudden jumping of schools of small fishes frequently disturbed the surface.

With the approach of fall (September, October, and November), the numbers of kinds and individuals reached a peak. Several lutianid and serranid species, together with filefishes, young sand trout and whiting, toadfish, mojarras, and others, invaded the flats in numbers only to leave within a relatively short time when, during September, the waters began to cool and the surface temperature started to fall. Heavy rains and a hurricane lowered the salinity considerably. The winds and waves of the storm ripped up large amounts of vegetation from the flats and covered some areas with sand. Fishes such as *Lagodon rhomboides, Bairdiella chrysura, Eucinostomus gula, Centropristes melanus, Cynoscion nebulosus,* and *Opsanus beta,* which had been among the more abundant forms, decreased in numbers in fall, and many species disappeared altogether.

Bottom Composition and Vegetation. The relative importance of these two interrelated environmental factors in the ecology of the fish population has been suggested previously. Two vital survival factors, food and protection, are correlated with the type of bottom and the presence or absence of vegetation. In the Cedar Key area, the greatest population and species densities were found in those zones of muddy sand bottom and thick vegetation. The food organisms harbored among the plants and in the substrate, together with the protection offered by the plant growth, appeared to operate as major factors governing the size and variety of the aggregation. The muddy sand and rock or shell-bottomed areas with sparse vegetation were the second most thickly inhabited regions, although again the population reflected the bottom composition and its pro-

visions, namely, food organisms and shelter. The least populated zones were those in which the bottom was composed of pure sand, since here protection was lacking and food was scarce.

Food. Thus far, in pointing out various environmental factors in the ecology of the shallow water fishes, reference has been limited chiefly to their inanimate surroundings. It is probable that physical factors most often and most strongly affect a given fish population indirectly by way of modifications of the biotic environment. Certainly one of the most basic of all environmental factors is food. It is common ecological knowledge that the total structure of the fish population is ultimately dependent upon the abundance of autotrophic phytoplankton organisms which capture radiant energy and manufacture food from the available inorganic constituents of sea water. Grazing upon these microscopic plant forms are minute zooplankton (and some larger forms), beginning what is probably the most complex of the biotic interrelationships, the food chain.

In the shallow waters of the Cedar Key area, macroscopic food organisms such as carid and peneid shrimps, portunid and xanthid crabs, mollusks, polychaetes, and small fishes were seasonally abundant. The most frequent and numerous items in the diet of the fishes collected during the present study consisted of fishes, shrimps, crabs, malacostracans, copepods and other microcrustaceans, mollusks, annelids, algae, and organic detritus.

On the basis of frequency of occurrence in the stomachs of small specimens of 51 species, copepods and other zooplankters were the items most frequently eaten. Shrimps were the second most frequently ingested organisms, with fishes, malacostracans, crabs, mollusks, worms, and algae following in that order of occurrence.

Only in the young of some species, *e.g.*, pinfish, pigfish, and flounders, and in small species such as the blennies and gobies did there appear to be any noticeable specificity for a particular food. It was observed that, generally, as the fish increased in size their feeding became more varied. For example, the serranids of small size subsisted almost wholly on microcrustaceans, but as the fish grew larger, shrimps and fishes became more important in the diet.

As would be expected, the habitats of various species were often reflected by the food organisms ingested. Surface forms such as *Menidia beryllina, Harengula pensacolae,* and *Anchoa mitchilli diaphana* usually consumed much phytoplankton and zooplankton; serranids and young lutianids, which inhabited grassy regions, took shrimps and fishes for food most frequently; sparids and sciaenids, which appeared to forage rather widely, ate worms more frequently than did most other fishes. Mollusks were eaten by sparids and by the more highly specialized forms (blennies, gobies, boxfish, batfish, etc.) which lived in rocky or shelly mud areas and which had mouth parts adapted for crushing the mollusk shells.

Predation. A vital environmental factor in shaping the structure of the fish population of the shallow water is predation. The inter-woven patterns of predator-prey relationships are much more complex than could be realized and defined from the present investigation. Generally, however, predation upon the fish population in the Cedar Key area appeared to involve three major agents: the larger piscivorous fishes, man, and the fish-eating birds.

Small fishes were utilized to considerable degree by most of the larger fishes, with such predation frequently beginning when the predator was still quite small. The numbers of fishes consumed by such voracious feeders as sharks, trout, lizardfish, flounders, mackerel, sea robins, carangid and serranid fishes, and a number of others, could hardly fail to produce effects on the densities of various species within the general population.

The direct influence of man on the fish population appeared to be more or less restricted to the commercially important species, especially the mullets, trouts, and redfish. The annual drain of thousands of mullets has doubtless had some effect in the population level.

Fish-eating birds were abundant in the Cedar Key area, and are protected on several of the islands which have been designated as government refuges. Gulls, cormorants, pelicans, egrets, and herons contributed to the general predation pressure. Scattergood (1950:507) reported on the stomach contents of five specimens of the cormorant, *Phalacrocorax a. auritus,* at Santa Rosa Sound, Pensacola, Florida. He found that three stomachs contained 15 *L. rhomboides,* ranging in size from 58 to 135 mm; one stomach contained one *Galeichthys felis,* 110 mm in length; one *Prionotus carolinus,* 228 mm in length; and two *Opsanus tau,* 101 and 109 mm in length; while the fifth bird had eaten one *Mugil cephalus,* 242 mm in length.

To return to the case of the mullet, it seems quite likely that predation by each of the three major agencies constitutes an important limiting factor in the population. It has been shown previously that the young spent several months in the most shallow waters, where they were subject to almost continuous predation by birds. Later they migrated to deeper regions where they could be preyed upon by larger fishes. In late fall and during winter, when the gonads of the adults were ripe, the fish were taken by fishermen, thus considerably suppressing the biotic potential of the fishes in the particular locality.

If the somewhat peculiar situation of the mullet be excepted, it seems reasonable to conclude that interspecific predation among the fishes of the shallow waters is, in general, rather light. Insofar as the data indicate, predation appeared to be most intense upon the species (young and adults) with the greatest density. Such forage fishes as the anchovies and silversides would fall into this group. It was further observed that populations of the predators themselves were by comparison small. Thus the predator drain on the forage fish fauna as a whole is not critically heavy.

Catastrophic Mass Mortality. Mass mortality of fishes due to various natural causes has been observed and reported frequently. The most common causes of widespread death to fishes reported for the Gulf are sudden freezes, discussed previously, and biological factors, the latter having become prominent lately as a result of considerable observation and study of the so-called "red-tide" (Gunter, *et al.,* 1948). Another natural catastrophe which occurs frequently along the Gulf coast of Florida is the hurricane, and, so far as is known, the effects of dilution and turbulence of the shallow waters on the fishes during a severe hurricane have not been appraised. On September 4, 1950, a hurricane with wind velocities reported at over 100 miles per hour struck Cedar Key and remained in the area for two days. The Gulf waters in the vicinity rose from three to four feet and the precipitation was great. Although rainfall data during

the hurricane were not obtained, 24 inches were recorded on September 6. The salinity of the water dropped from 23.5 to 9.7 ppt. during a period of four days. Observations made along the beach of Goose Cove on September 7, revealed thousands of dead fish washed up. On one segment of beach, approximately 3 x 450 feet in size, several hundred dead individuals were estimated. It was not determined if the mass mortality was restricted only to the shallow protected areas of Way Key, although several inhabitants stated that the outer beaches of the outlying islands were littered also. The most conspicuous species among the fishes killed are as follows:

Orthopristis chrysopterus
Mollienesia latipinna
Centropristes melanus
Bairdiella chrysura
Lagodon rhomboides
Fundulus similis
Sphoeroides nephelus
Syngnathus spp.
Chilomycterus schoepfi
Chasmodes saburrae
Menidia beryllina
Gymnothorax ocellatus saxicola
Monacanthus hispidus
Caranx hippos
Lactophrys tricornis
Diplectrum formosus
Ophidion holbrooki

Habitat Relationships. In the present study, only the most obvious major factors of the environment could be given consideration. Salinity, temperature, food, predation, and the gross biotic relationships are but a segment of the endless web of physical, chemical, and biological interplay that moulds the community. The relative importance of any single factor or group of factors in a natural community is difficult or impossible to evaluate with certainty. It has been suggested earlier that, on the whole, temperature is probably of more critical importance in the local fauna than salinity. Certainly food is also a major factor, with easily observable direct effect and, as has been shown, the composition of the bottom and the nature and extent of the vegetation exert controlling influences. From studies of the Massachusetts coast, Allee (1923: 246) concluded that bottom composition was more important than any other factor in the distribution of marine invertebrates in the littoral zones. Insofar as an appraisal of the relative importance of factors is justifiable, data from the Cedar Key investigation are in agreement with Allee's conclusion, since in the study area as a whole salinity and temperature were generally constant, whereas the important variable was composition of the substrate.

The various conspicuous habitats within the eulittoral segment at Cedar Key have been defined and described in an earlier section of this report. It was pointed out that the various zones, generally, harbored a more or less peculiar assemblage of fishes. However, the fishes were not narrowly restricted to given habitats, in most instances considerable interchange between areas having been observed.

Those species which did appear to be somewhat confined to particular habitats often showed interesting relationships. The most notable examples of habitat specificity were shown by *Ogcocephalus nasutus,* which seemed to be intimately associated with mud-rock bottom with sparse vegetation; by *Opsanus beta,* with market distributional correlation with muddy sand and shell or rock; and by *Chasmodes saburrae,* which adhered closely to intertidal areas of rock and

shell, although it did, occasionally, occur in other situations. All of these fishes are considered to be more highly specialized types. Their adaptations to areas where existence was doubtless more rigorous was reflected in their great tenacity of life. Whereas most of the less specialized fishes, such as the carangids, serranids, sparids, and gerrids, died quickly after being taken from the water, the blennies (represented by *C. saburrae*), *O. nasutus,* and *O. beta* could be handled and kept out of the water for some time without ill effects. As was shown previously, a specimen of *C. saburrae* remained alive in a conch shell for several hours after being taken from the water, and *O. beta* burrowed during the winter low tides. Each of these cases would seem directly related to the peculiar stringencies of the habitat occupied.

Ecologic isolation of sympatric species seemed evident in several cases. Shown below are four instances in which closely related species appeared to show marked habitat specificity within the region, and in this manner avoided what might have been severe inter-specific competition. Other genera were represented by more than one species, but in no other case were data sufficient to permit an evaluation of either the degree of competition or of adaptations tending to lessen it.

SPECIES	HABITAT
Eucinostomus gula	Open water flats
Eucinostomus argenteus	Marsh
Cynoscion nebulosus	Open water flats
Cynoscion arenarius	Channels
Gobiosoma robustum	Open water areas
Gobiosoma bosci	Marsh
Hippocampus regulus	Shallow flats
Hippocampus h. punctulatus	Deep flats and channels

Data from collections indicated that in one case temperature and/or salinity may have acted as isolating mechanisms. It appeared that *Monacanthus hispidus* was present during the warm months, although in reduced numbers during September and October, the months of lowest salinity, whereas *M. ciliatus* was present during the winter months and was caught in greatest numbers during the months of lowest salinity.

Zoogeographic Relationships

Faunal differences between the Atlantic and the Gulf coasts of Florida have been shown to exist in the distribution of certain vertebrate and invertebrate animals. Evermann and Kendall (1900:44) distinguished three more or less distinct faunal areas for the marine littoral of the peninsula: (1) an Atlantic coastal area extending from Fernandina to Biscayne Bay, (2) a subtropical area comprising the Florida Keys, with a fauna closely resembling that of Cuba, and (3) a Gulf coastal area. In commenting on the faunal regions these authors suggested:

> The warm waters of the keys serve as a more or less effective barrier to the passage of fishes living in colder water. As a result many species are found on the east coast of Florida which do not occur on the Gulf coast, and vice versa.

Subsequent studies on various groups of fishes have substantiated the essential validity of the faunal areas.

Results of the present study tend to confirm the faunal subdivisions proposed by Evermann and Kendall. Besides instances of variation that have received taxonomic recognition, certain Cedar Key fishes belonging to groups that have not been studied intensively show divergence from descriptions based on specimens from the Atlantic coast. Further divergence between the fish populations of the two coasts was indicated by comparisons of the species present in the Cedar Key area and their respective densities with available faunistic studies of Atlantic coast localities.

The Cedar Key fauna includes elements from at least three recognizable life areas. Insofar as existing published accounts of the faunas of Tortugas-Key West area, Texas, and North Carolina give a reliable picture for their respeceive regions, the Cedar Key assemblage seems most similar to that of Texas, although the fair number of tropical forms shared with the Tortugas-Key West area lends a degree of distinctiveness to the total faunal complex of the Cedar Key area.

Of the 58 families of fishes listed for Cedar Key, 49 were reported by Gunter (1945) for the Texas coast. Eight of the families found at Cedar Key and not taken by Gunter occur abundantly at Tortugas and are evidently of more tropical affinity. Such families as Echelidae, Ophichthyidae, Labridae, Scaridae, Blennidae, and Monacanthidae, important elements in the West Indian fauna and in that of Key West and Tortugas, are represented by lesser numbers of species at Cedar Key, and apparently are rare in the Gulf waters of Texas. Gunter's account of the Texas fauna included six families which were not found at Cedar Key, although three of these (Polynemidae, Mullidae, and Balistidae) occur at Key West and their presence in deeper areas at Cedar Key is probably to be expected. In several instances, families common to Cedar Key and Texas were found to be represented by greater numbers of species in the Cedar Key area. This was particularly striking in the serranids, lutianids, and sparids, while, conversely, flatfishes, sciaenids, and clupeids were found to have greater species density along the Texas coast.

The Key West fauna (Jordan, 1884) contains 50 families represented at Cedar Key, in addition to such families as Albulidae, Coryphaenidae, and Acanthuridae, which were not found in the Cedar Key area or along the Texas coast. The syngnathids, carangids, serranids, scorpaenids, gerrids, and labrids, which occur in both areas, have a greater species density at Key West. At Key West, as well as at Tortugas, the sciaenoid fishes, which are varied and abundant in Texas and at Cedar Key, are comparatively scarce. Jordan (*op. cit.*, 130) stated:

> The scarcity of Sciaenoid fishes is one of the most remarkable peculiarities of the fauna of the Florida keys and Cuba. The family is well represented along the coasts of the mainland. These fishes apparently prefer sandy shores to coral formations.

Ninety-seven families including approximately 400 species were recorded at Tortugas by Longley and Hildebrand (1941). The Cedar Key population includes only six families not found at Tortugas. In addition to the sciaenoid fishes previously mentioned, the poeciliids and cyprinodonts, conspicuous ele-

ments of the fish fauna of the mainland coastal marshes, are apparently absent from Tortugas. Some families present at Tortugas, and not found at Cedar Key, and some which are common to both areas, at Tortugas show marked increase in numbers of species and individuals.

An interesting aspect of faunal distribution between the South Atlantic and North Gulf areas is that shown by the sciaenoid fishes. The family is well represented on the Texas coast, at Cedar Key, and on the coast of North Carolina, but rare in the South Florida region. One sciaenoid species, *Micropogon undulatus* is one of the most abundant species along the Texas coast, and Smith (1907:318-319) reported it as also numerous on the coast of North Carolina. This species was not found at Cedar Key, nor was it recorded at Key West or Tortugas. Five species of triglids were reported by Longley and Hildebrand for Tortugas, and comparable numbers have been reported for the other Gulf localities and the North Carolina coast. None of the species of sea robins which occur at Tortugas was found at Cedar Key or commonly along the Texas coast. At Tortugas the species are apparently mostly deep water forms, whereas those of Cedar Key and Texas are more characteristically shallow water fishes. Three of the shallow water Gulf species (all of those found at Cedar Key) are represented by closely related forms on the Atlantic coast (Ginsburg, 1950).

The considerable degree of speciation shown by the East Gulf fish fauna would seem to indicate that mixing with the Atlantic population must be at a minimum, with temperature and bottom composition of the South Florida region as the possible operating barriers. If the southern tip of the Florida peninsula does offer some sort of obstacle to the coastwise migrations of shallow water fishes, then both the presence of the temperate water species in the northern Gulf and the differentiation that Atlantic and Gulf representatives have undergone may be explained as due to bisection of formerly continuous coastal ranges by the emergence of the Floridian plateau and the establishment of peninsular connections. Invasion of the northern Gulf regions by the more tropical fauna of Tortugas is doubtless inhibited by temperature differences and by the nature of the substrate.

The dominance of West Indian elements in the fauna of both the Atlantic and Gulf coasts of southern Florida has long been recognized. Several authors, in discussing the zoogeographic aspects of fish distribution, have pointed to the fact that little is known as to where the faunal complex undergoes transition from that of a temperate nature to that of a tropical one. (Gunter, *et al.,* 1948: 314; Ginsburg, 1952: 100).

Gunter, *et al.,* (*loc. cit.*) have indicated the tropical nature of the fauna of the lower West Florida beaches wherein the fish families Haemulidae, Sparidae, Hemiramphidae, and Gerridae become "increasingly important while the Sciaenidae and Otolithidae decrease in numbers." The region of Gunter's observations (Ft. Myers Beach) is approximately 200 miles south of the Cedar Key Area.

In Apalachee Bay, approximately 100 miles north of Cedar Key, the sciaenoid fishes are more abundant and the croaker, *Micropogon undulatus,* occurs there. The general fauna of Apalachee Bay appears to approach that of the temperate regions.

Evidence from the present study indicates, then, that the transition from the temperate fauna of the northern Gulf coast to the tropical, West Indian complex of the southern Gulf coast of Florida is a gradual one in which the southern forms begin to appear somewhat irregularly and seasonally while the species density of the northern fishes decreases.

Summary

1. In the vicinity of Cedar Key, Florida, the eulittoral zone is characterized by broad shallow areas known as "flats." The flats are cut by numerous deep channels and during the low tides of winter the bottom of the more shallow areas is exposed, while the deeper flats remain covered by water from two to three feet deep. During the warm months (March-October), the flats support abundant growths of spermatophytes and algae, the former being the dominant vegetation throughout most of the season. The bottom composition of the flats is mainly sandy mud or sand, while the channel bottoms are mostly shell and rock.
2. From June, 1950, to May, 1951, collections were made on an average of twice monthly from stations located in the major ecological situations: shallow flats, deep flats, and channels; and, in addition, exploratory collections were made along shallow beach zones and in offshore locations. Measurements of salinity, rainfall, water and air temperatures, and currents were made also. Collecting gear consisted principally of an otter trawl, supplemented by seines and other equipment.
3. Monthly mean surface temperatures ranged from 12.2°C. in December, to 28.9°C. in July, with an annual mean of 21.3°C. The monthly mean salinities varied from 19.9 ppt. in September, to 30.0 ppt. in June, with an annual mean of 25.7 ppt.
4. Over 13,000 specimens were examined during the study. One hundred and twenty-two species representing 100 genera and 58 families are included in an annotated list of fishes studied.
5. Although the composition of the fish population was found to vary seasonally, the conspicuous components were the young of such species as *Lagodon rhomboides, Orthopristis chrysopterus, Bairdiella chrysura, Eucinostomus gula, Centropristes melanus,* and *Cynoscion nebulosus.* Small fishes, such as pipefishes, sea horses, blennies, gobies, flatfishes, and sea robins were also characteristic of the shallow zone. Adult trout, redfish, mackerel, flounder, lizardfish, sharks, and rays were the most common of

the larger fishes in the area and were also the most prominent predators in the population.

6. The most densely populated habitats were the flats supporting lush vegetation which provided food and shelter for the fishes. The least inhabited regions appeared to be the shallow beach zones of pure sand.
7. Many species breed in the vicinity of Cedar Key, young fish being particularly common on the flats from late winter through summer.
8. Food studies revealed that the fishes generally found abundant food in the shallow zone. The principal food items were microcrustaceans, malacostracans, shrimps, annelids, mollusks, crabs, and fishes.
9. Mass mortality of fishes was caused by a hurricane, and the deleterious effects of such a catastrophe are discussed.
10. The Cedar Key fauna was found to consist mainly of species more characteristically associated with temperate climate. West Indian faunal elements, however, appear to be more conspicuous in the Cedar Key fauna than in that of Texas and North Carolina.
11. The presence of increased numbers of tropical forms together with the absence of certain sciaenoid species characteristic of the more temperate regions indicate that the transition to the tropical fauna of the southern Florida coast occurs in the vicinity of Cedar Key.

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CONTRIBUTIONS will be considered which deal with research in the marine sciences, directly or indirectly related to the southeastern United States and the Caribbean area. Papers dealing solely with the economic or applied aspects of commercial fisheries will not be accepted.

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